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Editorial

Shot-effect Noise Voltage in Valves

IN our July issue we published an article by J. McG. Sowerby entitled " Chart for Radio Noise." In the present number we publish a letter from R. E. Burgess criticising one of the formulae, and the author's reply. The subject of shot-effect is one of great complexity as one soon discovers on consulting the literature of the subject. In his well-known book " Spontaneous Fluctuation of Voltage," Moullin refers to the " great ignorance of the mechanism of the effect " and to " the mass of experiments which have not yet been interpreted." As is now well known, the electron emission from a valve filament is not a perfectly uniform current but an irregularly fluctuating one, and this fluctuation causes what is known as the shot noise. It also causes measurable fluctuations of the anode voltage, and the calculation of this noise voltage was the point at issue. In his article Mr. Sowerby made the tempting but apparently untenable assumption that the noise current may be regarded as a constant current originating at the cathode and flowing through the resistance R_a of the valve and the resistance R_L of the load or external circuit in series. He thus obtained the simple formula $\bar{e}_s = \bar{i}_s R_L$.

Let us now consider what would happen if we greatly increased R_L, but also correspondingly increased the anode battery voltage, so that the anode voltage and current remained unchanged. Conditions within the valve would be unaltered and the noise current, that is, the irregularities in the emission, would presumably be the same as before. If this current flowed through the very large external resistance, then $\bar{e}_s$ would be increased in the same proportion as the resistance R_L, and this greatly increased alternating noise voltage would be superimposed upon the normal anode voltage. Now experiments show that this great increase does not occur, but the smaller increase that is observed indicates that R_a and R_L must be assumed to be in parallel and not in series.

It must be remembered that the sudden increase of emission at any moment of peak emission is not uniform over the filament but occurs presumably at a number of points, the remainder of the filament having its normal emission and maintaining approximately the normal a.c. resistance of the valve. If this is a correct assumption, the valve may be regarded at every moment as equivalent to two valves in parallel, one carrying the shot current and the other of resistance R_a in parallel with it. The shot current wlll divide between R_a and the external resistance R_L and $\bar{e}_s = \bar{i}_s \dfrac{R_L R_a}{R_L + R_a}$. Now if R_L is made very large $\bar{e}_s$ will approximate to $\bar{i}_s R_a$. This result is confirmed by experiment.

The consideration of this problem suggests that we are too prone to regard the equivalent circuit, in which a source of e.m.f. equal to μe_g is pictured in series with a resistance R_a, as representing in some way the actual state of affairs within the valve. It is very doubtful if this equivalent circuit has any better claim to be so regarded than the alternative equivalent circuit in which a source of current equal to $\mu e_g/R_a$ is pictured in parallel with a resistance R_a. These two alternatives are examples of the dual form of the Helmholtz theorem to which we referred in the July editorial, and it is impossible to say that one is better than the other except as a matter of convenience of application. Neither pretends to represent the physical processes that go on inside the valve; they are merely alternative methods of calculation, but the shot-effect phenomena seem to fit in better with the parallel circuit picture.

G. W. O. H.

Vacuum Rectifiers Working with Condenser Input*

Graphical Assessment of Their Performance

By R. G. Mitchell. B.Sc.

SUMMARY.—Formulae are derived enabling curves to be drawn which give all the desired circuit data in terms of the known constants for vacuum rectifier circuits working with condenser input, in single-phase and bi-phase circuits.

1. Introduction

MANY articles have been written on the operation of vacuum rectifiers working with condenser input. Most of these, however, involve assumptions which greatly reduce the practical utility of the results, these usually being in the form of a number of formulae of limited application.

The most common assumption is that the capacitance of the reservoir condenser is infinite, so that the output voltage is completely free from ripple. In the case of high voltage circuits, however, it is often impracticable from either economic or space considerations to incorporate a condenser whose capacity is high enough to justify this assumption, or it may be that ripple is not of primary importance. Some scheme which takes condenser reactance into consideration is therefore desirable, and that factor is allowed for in this article.

On account of the complex nature of rectifier operation, however, *e.g.* the effect on the input voltage waveform of the intermittent flow of current, the nondescript waveform of the condenser ripple voltage, and the effect of transformer leakage, certain assumptions are inevitable. These are given below and the validity of each is discussed. The output voltage is greater, in the case of three-phase rectifier circuits, the ripple volts lower and the ripple frequency higher inherently than for single-phase and bi-phase circuits, so that in such circuits condenser input seldom yields any advantage. On this account single-phase and bi-phase circuits only are considered in this article.

2. Assumptions

(*a*) The input voltage is assumed sinusoidal. Oscillograph tests show that while this is not strictly correct, particularly when the transformer leakage reactance is appreciable, the departure from the sinusoidal form is most evident in the region of current cut-off, so that its effect is negligible, as far as the performance of the circuit is concerned.

(*b*) The effect of transformer leakage reactance is assumed to be negligible. The validity of this assumption has been investigated, and the results are included in this article. It is shown that, provided the transformer is reasonably well designed, this assumption is sound. Care must be taken, however, when high supply frequencies are employed, such as 500 c/s, and over.

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* MS. accepted by the Editor, December 1942.

(*c*) The discharge of the reservoir condenser is assumed linear. The validity of this assumption decreases as the minimum condenser voltage over a cycle of operation approaches zero, *i.e.* very high ripple. As, however, the accuracy of the scheme falls off under such conditions from other considerations, this region is not covered by the sets of curves given in this article.

(*d*) The rectifier characteristic is assumed linear. While this is not quite correct, a good estimate can usually be made of an equivalent resistance for the valve, and practical results show this to be valid. Moreover, it is usually necessary to add a fixed resistance in series with each valve in order to limit the peak charging current and the switching surges. As in addition there are the various circuit and transformer losses also effectively in series with the valve, the impedance of the latter is often only a fraction of the total charge impedance.

(*e*) The waveform of the reservoir condenser voltage during charge is assumed to be linear, but it is shown in Section 13 that the same results are obtained, assuming sinusoidal charge or any waveform which is horizontally symmetrical.

(*f*) It is assumed that the valve does not saturate during the charging cycle. The validity of this assumption depends on the valve and on the conditions of load, but in any case saturation is undesirable and should be avoided.

3. List of Symbols Employed

E = Peak transformer secondary voltage, per phase.
V = Mean D.C. output voltage.
η = Voltage conversion ratio, V/E.
δV = Amplitude of ripple voltage (unsmoothed).
K = $\delta V/V$.
I = Load current.
i = Instantaneous current in valve.
I_v = Mean current in valve.
$\hat{i}$ = Peak current in valve.
R = Load resistance.
R_a = Valve A.C. resistance.
r = Total charge resistance.*
ϕ_1 = Angle between point of commencement of current flow and peak input voltage. *See* Fig. 1a.
ϕ_2 = Angle between peak input voltage and point of current cut-off. *See* Fig. 1a.
$\phi = \frac{\phi_1 + \phi_2}{2}$ = half angle of current flow through each valve, per charging cycle.
t_D = Discharge period of reservoir condenser.
C = Capacitance of reservoir condenser.
X = Reactance of reservoir condenser at supply frequency.
f = Supply frequency.
D = Anode dissipation.
Ic = Condenser ripple current (R.M.S.).
i_c = Instantaneous condenser current.

4. Analysis for Linear Charge

If linear charge is assumed, the diagrammatic representation is as in Fig. 1a, from which it is seen that

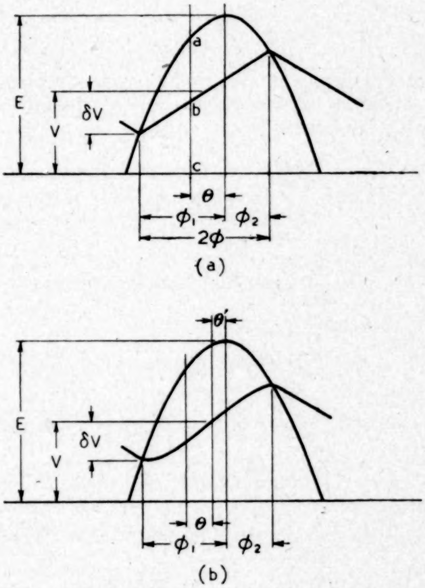

Fig. 1.—(a) *Linear charge*; (b) *sinusoidal charge*.

$$V - \delta V = E \cos \phi_1$$

and $$V + \delta V = E \cos \phi_2$$

Hence

$$\cos \phi_1 = \frac{V - \delta V}{E} = \frac{V - \delta V}{V} \,.\, \eta = \eta(1 - K)$$

and

$$\cos \phi_2 = \frac{V + \delta V}{E} = \frac{V + \delta V}{V} \,.\, \eta = \eta(1 + K)$$

Thus it follows that, if η and K are known, the angles ϕ_1 and ϕ_2 may be calculated.

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* r includes the valve resistance (2 in series in the single-phase full-wave circuit) + transformer losses + any added resistance.

Now at any angle θ the voltage charging the reservoir condenser through r is

$$ac - bc$$

i.e.
$$E\cos\theta - \left[E\cos\phi_1 + (E\cos\phi_2 - E\cos\phi_1)\frac{\phi_1+\theta}{\phi_1+\phi_2}\right]$$

It should be noted that θ varies between $-\phi_1$ and $+\phi_2$, over the charging cycle.

The instantaneous charging current at angle θ is

$$i = E/r\left[\cos\theta - \cos\phi_1 - (\cos\phi_2 - \cos\phi_1)\frac{\phi_1+\theta}{\phi_1+\phi_2}\right]$$

Integrating over a complete cycle we obtain a formula for the mean anode current per valve, as follows:—

$$I_v = \frac{E}{2\pi r}\int_{-\phi_1}^{+\phi_2}\left[\cos\theta - \cos\phi_1 - (\cos\phi_2 - \cos\phi_1)\frac{\phi_1+\theta}{\phi_1+\phi_2}\right]d\theta$$

$$= \frac{E}{2\pi r}\left[\sin\theta - \theta\cos\phi_1 - (\cos\phi_2 - \cos\phi_1)\frac{\phi_1\,\theta}{\phi_1+\phi_2} - (\cos\phi_2 - \cos\phi_1)\frac{\theta^2}{2(\phi_1+\phi_2)}\right]_{-\phi}^{+\phi_2}$$

$$= \frac{E}{2\pi r}\left[\sin\phi_1 + \sin\phi_2 - (\phi_1+\phi_2)\cos\phi_1 - (\cos\phi_2 - \cos\phi_1)\phi_1 - \frac{\cos\phi_2 - \cos\phi_1}{2}\,.\,(\phi_2 - \phi_1)\right]$$

$$= \frac{E}{2\pi r}\left[2\sin\phi\cos\frac{\phi_1-\phi_2}{2} - \phi_1\cos\phi_1 - \phi_2\cos\phi_1 - \phi_1\cos\phi_2 + \phi_1\cos\phi_1 \right.$$
$$\left. - \frac{\phi_2}{2}\cos\phi_2 + \frac{\phi_2}{2}\cos\phi_1 + \frac{\phi_1}{2}\cos\phi_2 - \frac{\phi_1}{2}\cos\phi_1\right]$$

$$= \frac{E}{2\pi r}\left[2\sin\phi\cos\frac{\phi_1-\phi_2}{2} - \frac{\phi_2}{2}\cos\phi_1 - \frac{\phi_1}{2}\cos\phi_2 - \frac{\phi_2}{2}\cos\phi_2 - \frac{\phi_1}{2}\cos\phi_1\right]$$

$$= \frac{E}{2\pi r}\left[2\sin\phi\cos\frac{\phi_1-\phi_2}{2} - (\cos\phi_1 + \cos\phi_2)\left(\frac{\phi_2}{2} + \frac{\phi_1}{2}\right)\right]$$

$$= \frac{E}{2\pi r}\left[2\sin\phi\cos\frac{\phi_1-\phi_2}{2} - (\cos\phi_1 + \cos\phi_2)\phi\right]$$

$$= \frac{E}{2\pi r}F(\phi, \phi_1, \phi_2)$$

It should be noted that ϕ_1 is always greater numerically than ϕ_2, the former approaching $\pi/2$ and the latter approaching zero as the ripple increases.

In the case of the single-phase half-wave rectifier circuit I_v is also the load current V/R, while in the bi-phase half-wave, and single-phase full-wave circuits the load current is twice this, i.e. $\frac{E}{\pi r}\,.\,F(\phi, \phi_1, \phi_2)$, as can be seen from Figs. 2, 3 and 4.

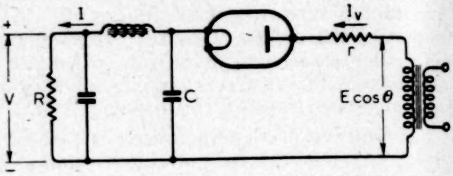


Fig. 2.—*Single-phase half-wave circuit.*

Now $\quad I = V/R = \frac{\eta\,.\,E}{R}$

Also $\quad V = \frac{E\cos\phi_1 + E\cos\phi_2}{2}$

Whence $\quad \eta = \frac{\cos\phi_1 + \cos\phi_2}{2}$

so that

$$E/R\,.\,\frac{\cos\phi_1 + \cos\phi_2}{2} = \frac{E}{2\pi r}\,.\,F(\phi, \phi_1, \phi_2)$$

in the single-phase half-wave circuit, and

$$= \frac{E}{\pi r}\,.\,F(\phi, \phi_1, \phi_2)$$

in the bi-phase half-wave and single-phase full-wave circuits.

$$\text{Hence} \quad R/r = \frac{\pi(\cos\phi_1 + \cos\phi_2)}{F(\phi, \phi_1, \phi_2)},$$

$$\text{and} \quad = \frac{\pi(\cos\phi_1 + \cos\phi_2)}{2F(\phi, \phi_1, \phi_2)}$$

in the respective cases.

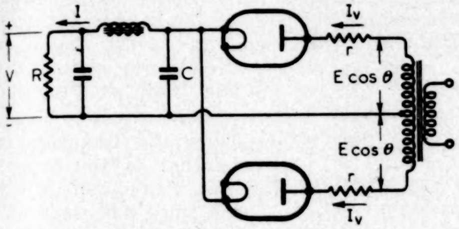


Fig. 3.—*Bi-phase half-wave circuit.*

$$\text{Now} \quad \frac{F(\phi, \phi_1, \phi_2)}{\cos\phi_1 + \cos\phi_2}$$

$$= \frac{\left[2\sin\phi\cos\frac{\phi_1 - \phi_2}{2} - \phi(\cos\phi_1 + \cos\phi_2)\right]}{\cos\phi_1 + \cos\phi_2}$$

$$= \left[\frac{2\sin\phi\cos\frac{\phi_1 - \phi_2}{2}}{2\cos\phi\cos\frac{\phi_1 - \phi_2}{2}} - \phi\right]$$

$$= [\tan\phi - \phi]$$

$$\text{Hence} \quad R/r = \frac{\pi}{\tan\phi - \phi} \quad \text{and} \quad \frac{\pi}{2(\tan\phi - \phi)}$$

in the respective cases.

This shows that the ratio R/r does not determine the angles ϕ_1 and ϕ_2, but only their sum, i.e. the total conduction period. The above expressions are in fact the same as are obtained assuming infinite reservoir capacitance (zero ripple) and show that the charging period depends only on R/r.

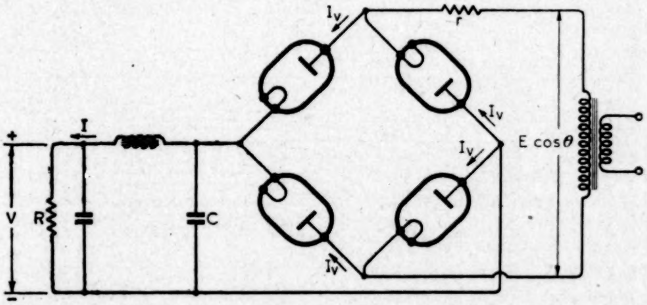


Fig. 4.—*Single-phase full-wave circuit.*

It is now possible, by choosing values for η and K, to calculate the corresponding values of R/r and so to plot curves of η against R/r with K as parameter. These are shown for the two cases in Fig. 5.

Now consider the discharge period, in which we have the relationship

$$2\delta V = \frac{I \,.\, t_D}{C}$$

$$\therefore \quad \delta V/V = K = \frac{I \,.\, t_D}{2C \,.\, V}$$

$$= \frac{t_D}{2CR}$$

$$= \frac{t_D}{2R} \,.\, \omega X$$

$$= \pi \,.\, f \,.\, t_D \frac{X}{R}$$

Now in the single-phase half-wave circuit

$$t_D = \frac{2\pi - 2\phi}{2\pi} \,.\, 1/f = \frac{\pi - \phi}{\pi \,.\, f}$$

Hence

$$K = (\pi - \phi)X/R = (\pi - \phi)X/r \,.\, r/R$$

$$\therefore \quad X/r = \frac{K}{\pi - \phi} \,.\, R/r$$

And in the bi-phase half-wave and single-phase full-wave circuits

$$t_D = \frac{\pi - 2\phi}{\pi} \,.\, \tfrac{1}{2}f = (\pi/2 - \phi)1/\pi f$$

$$\text{whence} \quad K = (\pi/2 - \phi)X/R$$

$$\therefore \quad X/r = \frac{K}{\pi/2 - \phi} \,.\, R/r$$

Then if we choose the same series of values of K and η as were employed in order to construct Fig. 5, we can calculate the corresponding values of X/r, as R/r and ϕ are known. Curves can then be drawn giving η against X/r with K as parameter, as shown in Figs. 6 and 7.

The most convenient form in which the relationships can be expressed is in sets of curves having R/r as abscissa and X/r as parameter. This is done as follows.

Choosing a series of even values of X/r we obtain from Figs. 6 and 7 the values of V/E corresponding to the various values of the parameter K. Then the corresponding values of R/r can be obtained from Fig. 5. V/E and K may then be plotted against R/r with X/r as parameter. These curves are given in Figs. 8, 9, 10 and 11, except that K is converted to percentage R.M.S. ripple voltage relative to V, i.e. $K/\sqrt{2} \times 100$.

The ripple frequency is twice that of the supply except in the case of the single-phase half-wave circuit, in which the ripple and supply frequencies are equal.

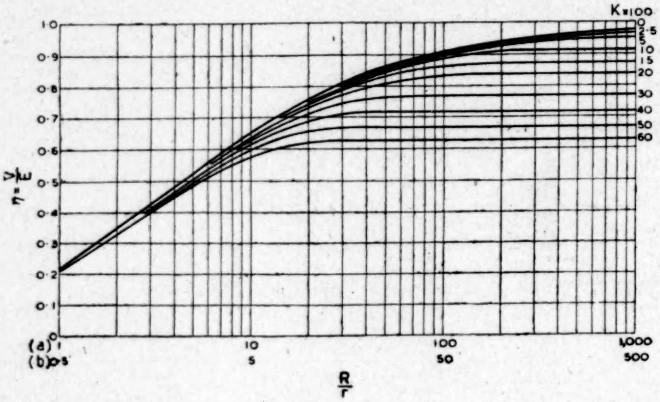


Fig. 5.—*Horizontal scale* (a) *for single-phase half-wave circuit,* (b) *for bi-phase half-wave and single-phase full-wave circuits.*

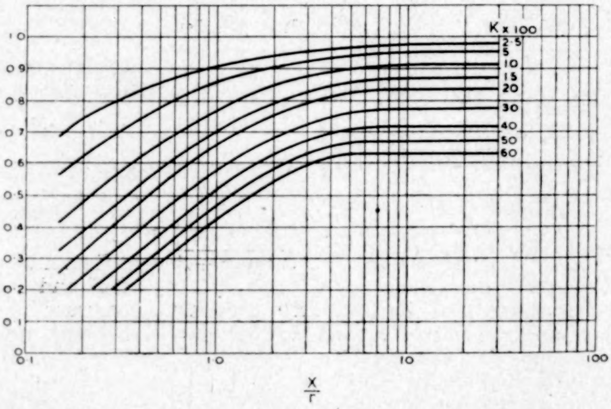
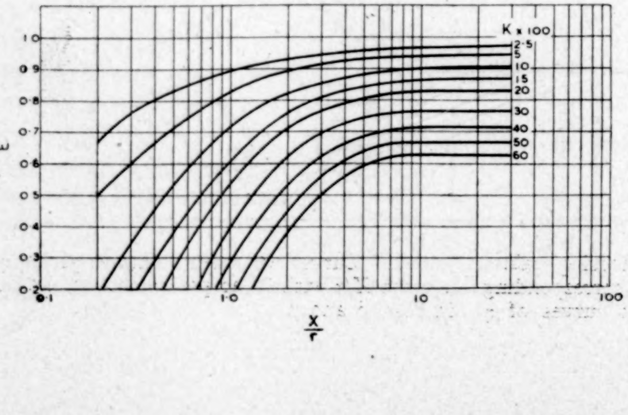


Fig. 6 (Right).—*Single-phase half-wave circuit.*

Fig. 7 (Below).—*Bi-phase half-wave, and single-phase full-wave circuits.*



5. Peak Charging Current

It is usually desirable to know approximately the value of the peak charging current flowing through the valves. This can be assessed by means of curves giving the ratio $\hat{i}/I_v$ in terms of the known constants.

The simplest method is to assume the current pulse to be part of a sine wave of supply frequency, the ratio

$\hat{\imath}/I_v$ being obtained from the conduction angle, which depends on R/r, from the familiar formula $\dfrac{\pi(1 - \cos\phi)}{\sin\phi - \phi\cos\phi}$. In practice, however, the values obtained are appreciably higher than this formula leads us to expect.

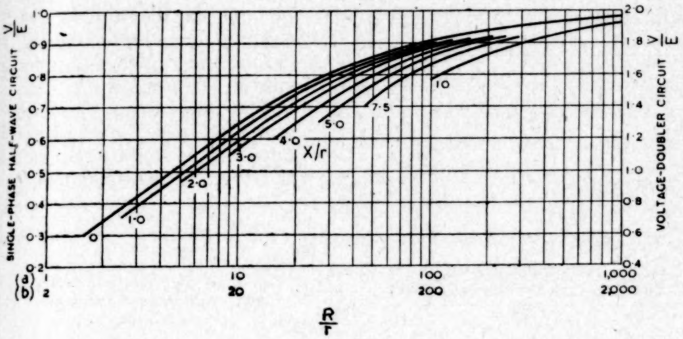


Fig. 8.—*Horizontal scale* (a) *for single-phase half-wave circuit,* (b) *for voltage-doubler circuit.*

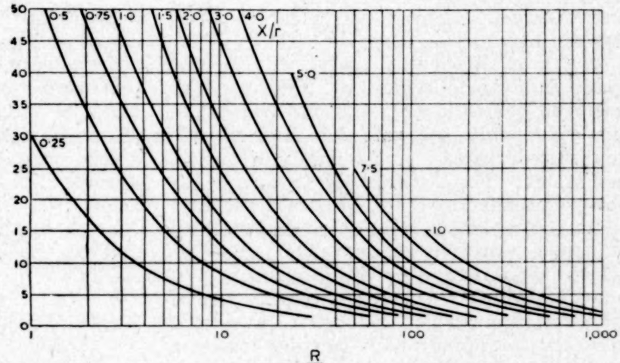


Fig. 9 (Right).—*Single-phase half-wave circuit.*

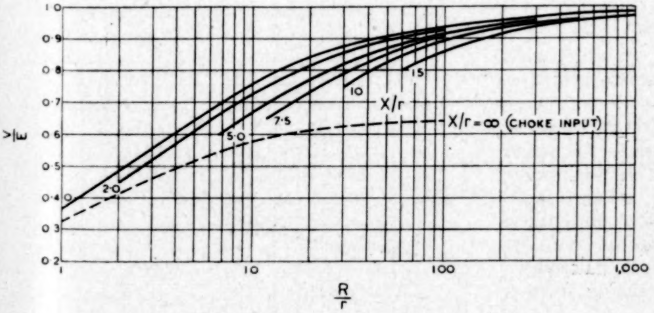


Fig. 10 (Below).—*Bi-phase half-wave and single-phase full-wave circuits.*

The method which gives the most accurate results is based on the assumption that the current pulse is a complete half sine wave flowing over the charging period 2ϕ. This means that the extrapolated wave would have a frequency higher than that of the supply.

Then i at any point θ measured from $\hat{\imath}$ is equal to

$$\hat{\imath}\cos\left[\theta \,.\, \frac{\pi}{2\phi}\right]$$

Then

$$I_v = \hat{\imath}/\pi \int_0^{\phi} \cos\left[\theta \,.\, \frac{\pi}{2\phi}\right] d\phi$$

$$= \hat{\imath}/\pi \left[\frac{2\phi}{\pi}\sin\theta\,\frac{\pi}{2\phi}\right]_0^{\phi}$$

$$= \frac{\hat{\imath}\,.\,2\phi}{\pi^2}$$

Hence

$$\hat{\imath}/I_v = \frac{\pi^2}{2\phi} = \frac{\pi}{2}\,.\,\frac{\pi}{\phi} = 1{\cdot}57\,\pi/\phi$$

Apart from the higher accuracy obtained by this method, oscillograph tests suggest that the assumption made is more valid than that discussed above. The results obtained in practice are still, however, rather higher than the theoretical.

The curves giving $\hat{\imath}/I_v$ against V/E, with ripple as parameter, are shown in Fig. 12.

Curves may also be produced from formulae obtained by differentiation of, and substitution of the angle of maximum current in, the formula for i in Section 4. The results are, however, slightly less accurate than those in Fig. 12.

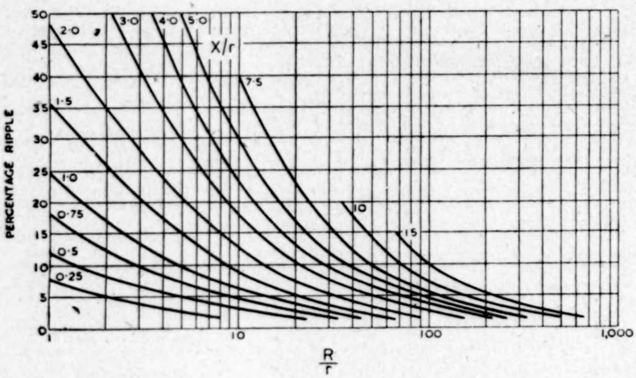


Fig. 11.—*Bi-phase half-wave and single-phase full-wave circuits.*

As $\hat{i}/Iv$ is shown to depend solely on the conduction angle, which in turn depends solely on the ratio R/r, it would seem that one curve only, showing $\hat{i}/Iv$ against R/r is required, instead of the family of curves in Fig. 12. The accuracy of assessment is, however, limited by the validity of the several assumptions, which falls off at high values of ripple. On this account the family of curves in Fig. 12 are preferable as they cover only the field of reasonable accuracy, and so give a warning when the region of reduced accuracy is approached. In such cases a single curve of $\hat{i}/Iv$ would be misleading.

6. The Voltage-Doubler Circuit

This circuit is shown in Fig. 13 which also includes a graphical representation of the various voltages.

The functioning of this circuit may be clearly understood if one imagines the point y in Fig. 13 (a) to be joined to the mid-point of the load, which must be at the same potential, assuming identical condensers. It is then seen that the circuit consists effectively of two single phase half wave rectifier circuits in series, operating from a common supply.

This still applies when the smoothing circuit, omitted from the diagram for the sake of clarity, is inserted.

Now consider one single-phase half-wave section only. Obviously its characteristics can be determined from the curves of Figs. 8 and 9, using $R/2$ instead of R. The output voltage for the complete circuit is then twice that for one section, and so Fig. 8 may be adapted to include the voltage-doubler circuit as shown.

The percentage ripple is not obtained so readily, however, owing to the fact that, while one condenser is charging, the other is discharging, as shown in Fig. 13 (b).

Examination of Fig. 13 (b) shows that the peak ripple voltage is actually less for the complete circuit than for each individual section, so that the over all percentage ripple is less than half that for each individual section. The actual values are obtained as follows :—

From the diagram in Fig. 13 (b) we see that the peak over all ripple voltage $\delta V = ab - cd$

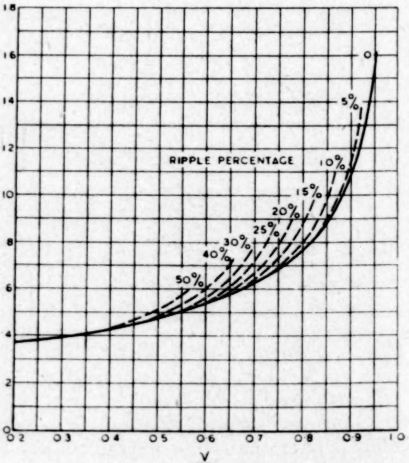


Fig. 12.

$$\therefore \quad \delta V = \delta Vs - \delta Vs \, . \frac{\phi}{\pi - \phi}$$

$$= \delta Vs \left(1 - \frac{\phi}{\pi - \phi} \right)$$

Where δVs is the ripple peak for each single-phase half-wave section.

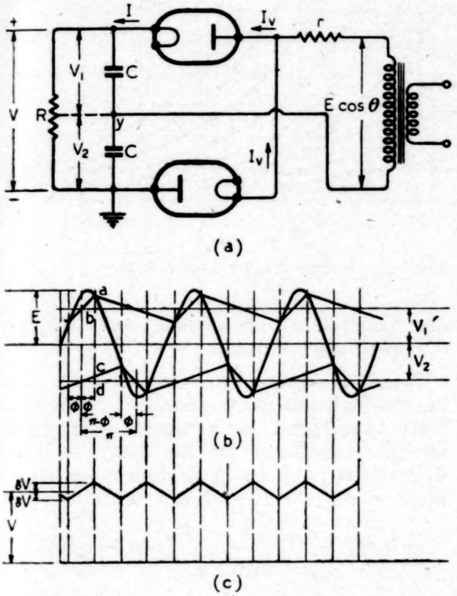


Fig. 13.—(a) *Voltage-doubler circuit*, (b) *Voltages relative to point y*, (c) *Resultant output voltage.*

Now δVs, V and ϕ can be calculated as shown in Section 4, assuming values for η and k, provided R, r and C are known.

Hence δV can be calculated and the percentage ripple plotted against R/r with X/r as parameter, as shown in Fig. 14.

N.B.—The ripple frequency is twice that of the supply.

The values of $\hat{i}/Iv$ may be obtained by considering one single-phase half-wave section. The values of ripple and V/E are assessed from Figs. 8 and 9, using $R/2$ instead of R. The ratio is then obtained from Fig. 12 as before.

7. Experimental Tests

Tests were made on all the circuits concerned, under various conditions of load, feed, etc., using U15 rectifier valves. The results, as will be seen from the samples given in Tables I, II & III, show that the accuracy is high, particularly in the case of the most important factors, namely, output voltage and percentage ripple.

Tests on a single-phase full-wave circuit gave the same order of accuracy.

The tests show that the ratio $\hat{i}/Iv$ is substantially independent of C, as was expected from the analysis in Section 5.

8. Anode Dissipation

This may be approximately assessed as follows. As anode dissipation depends on the current waveform this is assumed to be a complete half sine wave as in Section 5.

Then $i = \hat{i} \cos [\theta \, . \, \pi/2\phi]$

Dissipation at any instant θ is thus

$$= i^2 \, . \, Ra$$

$$= \hat{i}^2 \, . \, Ra \, . \cos^2 [\theta \, . \, \pi/2\phi]$$

TABLE I. SINGLE-PHASE HALF-WAVE CIRCUIT.
(R.M.S. Input—750 volts.)

r	*R*	*R/r*	*C*	*X/r*	D.C. Output Volts		Percentage Ripple		$\hat{i}/Iv$	
Ohms	Ohms		μF		Theoretical	Experimental	Theoretical	Experimental	Theoretical	Experimental
800	20,000	25	8	0·5	824	825	3·8	3·3	7·2	7·4
,,	,,	,,	4	1	816	818	7·3	7·0	7·2	7·4
,,	,,	,,	2	2	795	790	13·8	12·5	7·0	7·4
,,	,,	,,	1	4	730	718	29	27	7·0	7·4
600	20,000	33	8	0·67	858	860	3·5	3·4	8·0	8·5
,,	,,	,,	4	1·33	848	853	7·0	6·7	8·0	8·4
,,	,,	,,	2	2·66	825	823	14	12·8	8·0	8·4
,,	,,	,,	1	5·33	725	723	31	27·5	7·5	8·3

Then dissipation over a cycle of operation $(= D)$

$$= \frac{\hat{i}^2 . Ra}{\pi} \int_0^{\phi} \cos^2 [\theta . \pi/2\phi] \, d\theta$$

$$= \frac{\hat{i}^2 . Ra}{\pi} \left[\frac{\theta}{2} + \frac{\phi}{2\pi} \sin \theta . \frac{\pi}{\phi} \right]_0^{\phi}$$

$$= \frac{\hat{i}^2 . Ra}{\pi} . \frac{\phi}{2}$$

$$= \hat{i}^2 . Ra . \frac{\phi}{2\pi}$$

Now in Section 5 we obtained the relationship

$$\hat{i}/Iv = 1.57 \, \pi/\phi$$

Therefore

$$D = \left(Iv^2 . Ra . \frac{\phi}{2\pi} \right) . \left(1.57^2 . \frac{\pi^2}{\phi^2} \right)$$

$$= 1.24 \, Iv^2 . Ra . \pi/\phi$$

$$= Iv^2 . Ra . F_D, \text{ where } F_D = 1.24 \, \pi/\phi$$

F_D can thus be plotted against V/E with ripple as parameter, as shown in Fig. 15.

This factor also enables us to calculate the dissipation in the added feed resistance, should any be incorporated, the appropriate values being substituted for Iv and Ra in the above formula. It should be remembered that in certain cases the mean current through the added feed resistance is twice the mean valve current.

The accuracy of the assessment of anode dissipation is of the same order as that of $\hat{i}/Iv$.

9. Transformer Secondary Current

The R.M.S. current in the transformer secondary may be calculated as follows for the various circuits.

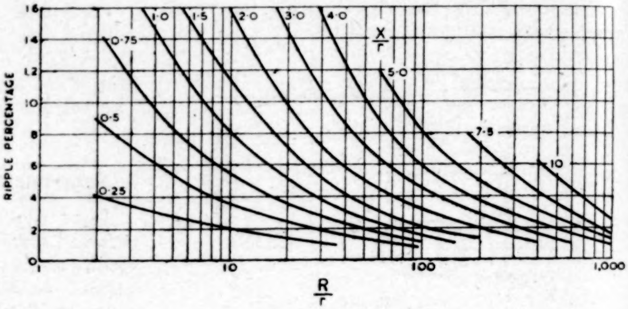


Fig. 14.—*Voltage-doubler circuit.*

(a) *Single-phase Half-wave and Bi-phase Half-wave Circuits*

Consider the charging current pulse flowing through the feed resistance r. Then the watts dissipated in r must be the same whether calculated on the basis of a unidirectional pulse as in Section 8, or on the basis of the effective R.M.S. current, i.e.

$$I^2_{\text{R.M.S.}} . r = Iv^2 . r . F_D$$

$$\therefore \quad I_{\text{R.M.S.}} = Iv\sqrt{F_D}$$

In the bi-phase circuit this is the current per leg of the transformer secondary, Iv being half the load current.

TABLE II. BI-PHASE HALF-WAVE CIRCUIT.

(R.M.S. Input—1,000 volts.)

r	R	R/r	C	X/r	D.C. Output Volts		Percentage Ripple		$\hat{i}/Iv$	
Ohms	Ohms		μF		Theoretical	Experimental	Theoretical	Experimental	Theoretical	Experimental
800	20,000	25	8	0·5	1,213	1,202	1·4	1·4	8·8	9·0
,,	,,	,,	4	1	1,204	1,196	3·1	2·7	8·7	9·0
,,	,,	,,	2	2	1,188	1,188	6·0	5·2	8·6	9·1
,,	,,	,,	1	4	1,152	1,150	10·8	10	8·6	9·1
,,	,,	,,	0·5	8	1,060	1,045	22	22	8·6	9·1
800	10,000	12·5	8	0·5	1,102	1,105	2·5	2·3	7·2	7·45
,,	,,	,,	4	1	1,094	1,090	5·3	5·0	7·15	7·45
,,	,,	,,	2	2	1,065	1,070	10.5	9·3	7·0	7·44
,,	,,	,,	1	4	1,020	1,025	20	19	7·0	7·3
,,	,,	,,	0·5	8	920	913	37·5	35	6·8	6·5

(*b*) *Single-phase Full-wave and Voltage-doubler Circuits*

On the same reasoning as above it is seen that

$$I^2_{\text{R.M.S.}} \,.\, r = 2Iv^2 \,.\, r \,.\, F_D,$$

as current flows through r on both half cycles.

Hence $I_{\text{R.M.S.}} = Iv\sqrt{2F_D}$

Iv is half the load current in the single phase full wave circuit, but equal to the total load current in the voltage-doubler circuit.

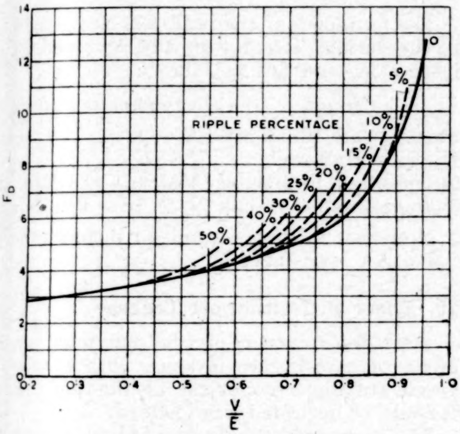


Fig. 15.

10. Condenser Ripple Current (R.M.S.)

As in the case of some condensers a limit is set as regards the permissible R.M.S. ripple current, it is desirable to have some means of assessing that factor. This may be accomplished as follows.

Consider the charging pulse to be a complete half sine wave flowing over an angle 2ϕ as in Section 5. Then in the single-phase half-wave circuit the value of ic between the angles $-\phi$ and $+\phi$ is

$$\hat{i}\cos[\theta \,.\, \pi/2\phi] - I$$

and between $+\phi$ and $2\pi - \phi$ it is constane and equal to I.

The mean square of i_c is thus

$$1/2\pi\int_{-\phi}^{+\phi}\Big[\hat{i}\cos(\theta \,.\, \pi/2\phi) - 1\Big]^2 d\theta + 1/2\pi\,(2\pi - 2\phi)I^2$$

$$= 1/2\pi\int_{-\phi}^{+\phi}\Big[\hat{i}^2 \,.\, \cos^2(\theta \,.\, \pi/2\phi) - 2I \,.\, \hat{i} \,.\, \cos(\theta \,.\, \pi/2\phi) + I^2\Big]\,d\theta + \frac{\pi - \phi}{\pi} \,.\, I^2$$

$$= 1/2\pi\Big[\hat{i}^2 \,.\, \theta/2 + \hat{i}^2 \,.\, \phi/2\pi \,.\, \sin(\theta \,.\, \pi/\phi) - 4\phi \,.\, I \,.\, \hat{i}/\pi \,.\, \sin(\theta \,.\, \pi/2\phi) + I^2 \,.\, \theta\Big]_{-\phi}^{+\phi} + \frac{\pi - \phi}{\pi} \,.\, I^2$$

$$\doteq 1/2\pi\Big[\hat{i}^2 \,.\, \phi - 8\phi/\pi \,.\, I \,.\, \hat{i} + I^2 \,.\, 2\phi + 2\pi \,.\, I^2 - 2\phi \,.\, I^2\Big]$$

$$= 1/2\pi\Big[\hat{i}^2 \,.\, \phi - 8\phi/\pi \,.\, I \,.\, \hat{i} + 2\pi \,.\, I^2\Big]$$

$$= \Big[\hat{i}^2 \,.\, \phi/2\pi - 4\phi/\pi^2 \,.\, I \,.\, \hat{i} + I^2\Big]$$

Hence $Ic = \sqrt{[\hat{i}^2 \,.\, \phi/2\pi - 4\phi/\pi^2 \,.\, I \,.\, \hat{i} + I^2]}$

Now from Section 5 we have $\hat{i}/Iv (= \hat{i}/I$ in the single-phase half-wave case)

$$= \pi/2 \,.\, \pi/\phi$$

$$\therefore \quad Ic = \sqrt{\pi^2/4 \,.\, \pi^2/\phi^2 \,.\, \phi/2\pi \,.\, I^2 - 4\phi/\pi^2 \,.\, \pi/2 \,.\, \pi/\phi \,.\, I^2 + I^2}$$

$$= I\sqrt{\pi^2/8 \,.\, \pi/\phi \,.\, - 2 + 1}$$

$$= I\sqrt{1.234\ \pi/\phi - 1}$$

TABLE III. VOLTAGE-DOUBLER CIRCUIT.
(R.M.S. Input—700 volts.)

r	R	R/r	C	X/r	D.C. Output Volts		Percentage Ripple		$\hat{i}/Iv$	
Ohms	Ohms		μF		Theoretical	Experimental	Theoretical	Experimental	Theoretical	Experimental
500	40,000	80	4	1·6	1,160	1,155	2·8	3·4	8·6	9·7
,,	,,	,,	2	3·2	1,115	1,100	5·6	6·2	8·4	9·8
,,	,,	,,	1	6·4	975	960	11·5	12·2	7·5	9·2
800	40,000	50	4	1	1,085	1,080	2·6	3·15	7·15	8·3
,,	,,	,,	2	2	1,058	1,040	4·8	5·7	7·15	8·4
,,	,,	,,	1	4	964	940	10·0	11·6	7·2	8·2

Then, as ϕ is determined by the circuit constants R and r, Ic/I may be plotted against V/E with ripple as parameter, as shown in Fig. 16.

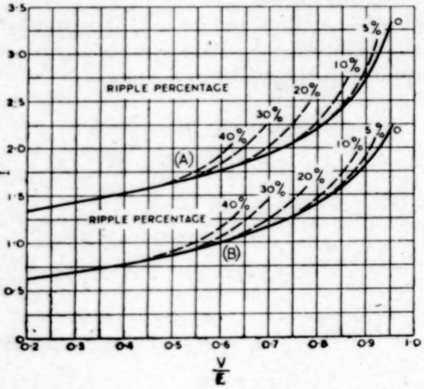


Fig. 16.—*Curve (A) Single-phase half-wave circuit. Curve (B) Bi-phase half-wave and single-phase full-wave circuits.*

In the bi-phase half-wave and single-phase full-wave circuits the charging current pulse occurs twice in each cycle of the applied voltage, so that in these circuits the mean value of ic^2 is

$$1/\pi\int_{-\phi}^{+\phi}\left[\hat{i}\cos(\theta.\pi/2\phi)-I\right]^2 d\theta+I^2\frac{(\pi-2\phi)}{\pi}$$

$$=1/\pi\left[\hat{i}^2.\phi-8\phi/\pi.I.\hat{i}+2I^2.\phi+I^2.\pi-2I^2.\phi\right]$$

$$=1/\pi\left[\hat{i}^2.\phi-8\phi/\pi.I.\hat{i}+I^2.\pi\right]$$

$$\therefore\quad Ic=\sqrt{\hat{i}^2.\phi/\pi-8I.\hat{i}.\phi/\pi^2+I^2}$$

now

$$\hat{i}/Iv=\pi/2.\pi/\phi\quad\therefore\hat{i}/I=\pi/4.\pi/\phi,\text{ as }I=2Iv$$

$$\therefore\quad Ic=\sqrt{I^2.\phi/\pi.\pi^2/16.\pi^2/\phi^2-8I^2.\phi/\pi^2.\pi/4.\pi/\phi+I^2}$$

$$=\sqrt{I^2.\pi^2/16.\pi/\phi-2I^2+I^2}$$

$$=I\sqrt{0.617\,\pi/\phi-1}$$

Ic/I may then be plotted as shown in Fig. 16.

In the voltage-doubler circuit the assessment is made by considering one single-phase half-wave section, as in the assessment of $\hat{i}/Iv$.

Experimental tests showed that in practice the values of Ic/I are slightly higher than indicated by the curves. This was expected in view of the fact that a similar variance was noticed in the assessment of $\hat{i}/I$, the theoretical determination of which was based on the same assumption as to charge waveform.

11. Peak Reverse Voltage

The formulae for the peak reverse voltages in the various circuits may be obtained by inspection, and are as follows.

Circuit.	*Peak Reverse Voltage*
Single-Phase Half-wave	$E + V$
Bi-phase Half-wave	$E + V$
Single-Phase Full-Wave	$V + (E - V)\,Ra/r$
Voltage-Doubler Circuit	$V + (E - V/2)Ra/r$

Note that in these formulae r includes the valve A.C. resistance.

12. Effect of Transformer Leakage

Tests were carried out to determine the effect of transformer leakage, with a view to ascertaining how far the assumption that it could be neglected was justified.

The tests were made by adding various reactances of known value externally, and noting the effect produced on the various circuit constants. The effect on the voltage ratio V/E is shown in Figs. 17 and 18, the dotted curves representing the values obtained when the leakage indicated, expressed as a ratio of r, was inserted. The curves show

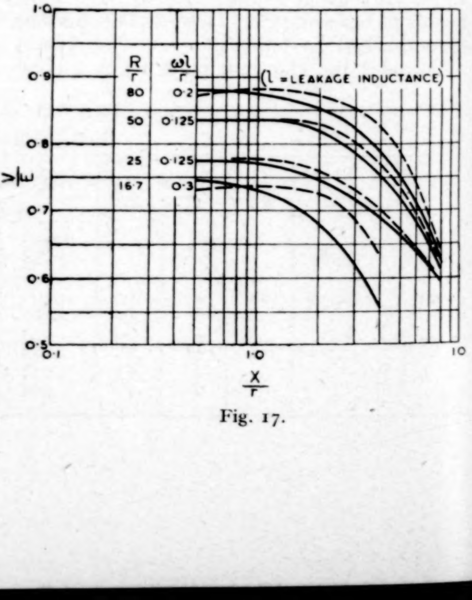


Fig. 17.

that the change produced is practically independent of the ratio R/r, but depends mainly on the ratio wl/r. Provided this does

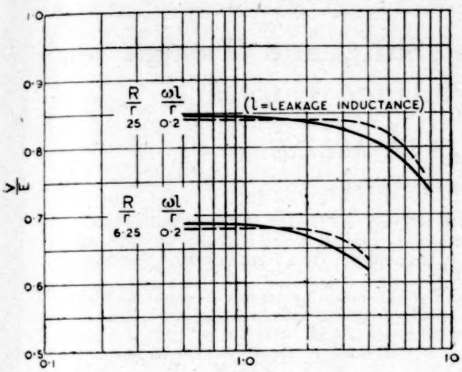


Fig. 18.

not exceed 0.1 the change produced is negligible.

The effect on the percentage ripple was not measurable under any circumstances, while the ratio $\hat{\imath}/Iv$ was only affected correspondingly with V/E.

The main effect of leakage is seen to be an increase in output voltage. This is probably due partly to an increase in the charging period and to a lesser extent to the tendency of the reactance to cancel an equal amount of the condenser reactance. The former effect is not difficult to appreciate as, while the inductance cannot delay the commencement of current flow, it can delay the current cut-off. Large values of leakage produce considerable wave-form distortion, as was shown by oscillograph tests.

The peculiar phenomenon whereby leakage tends to keep the output voltage constant over a considerable range of values of X/r suggests that a certain amount of leakage is not undesirable. In large installations leakage is exploited in order to limit the currents, should faults develop.

13. Sinusoidal Charge Analysis

It can be shown that the results of the analysis in Section 4 in which linear charge was assumed, are also obtained assuming sinusoidal charge. The waveform in this case is shown in Fig. 1 (b). It should be noted that this is a complete half sine wave flowing over the charging period 2ϕ, and not over 180° of the supply cycle.

It is convenient for the purpose of this analysis to take the centre of the charging period as our reference point, θ' being the interval between this and the point of maximum input voltage E.

Then i at any point θ

$$= E/r\left[\cos(\theta+\theta') - \cos\phi_1 - \frac{\cos\phi_2 - \cos\phi_1}{2} + \frac{\cos\phi_2 - \cos\phi_1}{2}\sin\theta \cdot \frac{\pi}{\phi_1+\phi_2}\right]$$

$$\therefore\quad Iv = \frac{E}{2\pi r}\int_{-\phi}^{+\phi}\left[\cos(\theta+\theta') - \cos\phi_1 - \frac{\cos\phi_2 - \cos\phi_1}{2} + \frac{\cos\phi_2 - \cos\phi_1}{2}\,.\sin\theta\,\frac{\pi}{\phi_1+\phi_2}\right]$$

The final term cancels out over the complete half-cycle, so that

$$I = \frac{E}{2\pi r}\left[\sin(\theta+\theta') - \theta\frac{\cos\phi_1 + \cos\phi_2}{2}\right]_{-\phi}^{+\phi}$$

$$= \frac{E}{2\pi r}\left[\sin\phi_1 + \sin\phi_2 - \phi(\cos\phi_1 + \cos\phi_2)\right]$$

$$= \frac{E}{2\pi r}\left[2\sin\phi\cos\frac{\phi_1-\phi_2}{2} - \phi(\cos\phi_1 + \cos\phi_2)\right]$$

This is the same expression as was obtained in Section 4 for the case of linear charge. As the discharge analysis is not affected, the curves obtained from the formulae in Section 4 hold for the sinusoidal charge assumption.

It will be appreciated in fact that the same results will be obtained assuming any charge waveform that is horizontally symmetrical.

The current waveform will vary somewhat in the two cases, the peak occurring earlier in the cycle in the case of sinusoidal charge. The ratio $\hat{\imath}/Iv$ is not, however, appreciably different.

Coupled Circuit Filters[*]

Generalised Selectivity, Phase Shift, and Trough and Peak Transfer Impedance Curves

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SUMMARY.—Generalised selectivity curves developed by Beatty for identical coupled tuned circuits are shown to be applicable to dissimilar coupled tuned circuits of differing Q, L, and C values but having a common resonant frequency. The term common resonant frequency signifies that

(1) either the resonant frequency of the primary and coupling circuit is equal to that of the secondary and coupling circuit, (for shunt coupling the circuit not being considered is on open circuit and for series coupling it is short circuited),

(2) or the resonant frequencies of the primary and secondary circuits, in the absence of coupling, are equal.

Generalised selectivity curves of loss in decibels and of phase shift are given in terms of a function of off-tune frequency for selected values of coupling coefficient, k, and the magnifications Q_1 and Q_2 of the primary and secondary circuits.

An example is worked to show their application.

Generalised transfer impedance curves for the trough and peak frequency responses are given for different values of $\sqrt{Q_1 Q_2}\,k$. Maximum transfer impedance $Z_T = \frac{1}{2}\sqrt{R_{D1} R_{D2}}$ (R_{D1} and R_{D2} are the dynamic resistances of the primary and secondary circuits respectively) is obtained at a value of coupling coefficient, $k = 1/\sqrt{Q_1 Q_2}$, which is less (except when $Q_2 = Q_1$) than that required for critical coupling, i.e., the coupling which, if exceeded, produces double peaked response. Critical coupling coefficient equals $\sqrt{\frac{1}{2}\left(\frac{1}{Q_1^2} + \frac{1}{Q_2^2}\right)}$.

For couplings exceeding that required for maximum Z_T, the peak or peaks fall, and curves are given for determining this reduction with different values of $\frac{Q_2}{Q_1}$.

For any given external damping resistances, e.g., due to the slope resistance (R_a) of the preceding valve, and the input resistance, R_g, of the following valve, maximum transfer impedance for a particular selectivity characteristic is obtained when

$$Q_1 = Q_2 \text{ and } \frac{L_2}{L_1} = \frac{R_g}{R_a}$$

Shunt and series inductance and capacitance couplings are examined and it is shown that the generalised curves are here applicable if certain terms, which are indicated, can be neglected. Generally this is possible. The two special cases of a common resonant frequency are detailed and expressions for transfer impedance, mid-frequency and coupling coefficient are derived.

The effects of resistance in the coupling element and of mistuning of the primary and secondary circuits are considered, and in the latter instance it is shown that the generalised curves may be applied if certain conditions are fulfilled. The influence of a frequency ratio factor, which is assumed to be 1 when determining the generalised selectivity curves, is discussed.

Definitions are given of the important parameter $\sqrt{Q_1 Q_2}\,k$ and of the coupling coefficient k in terms of the coupling, primary and secondary reactances and resistances for shunt coupling, and susceptances and conductances for series coupling.

1. Introduction

JUST on ten years ago R. T. Beatty[1] published his generalised selectivity curves for two element band-pass filters but limited his examination to coupled circuits of identical LC and Q values. This convenient condition cannot always be realised in practice, e.g., the slope resistance of the valve connected to the primary, and the grid input resistance of the valve connected to the secondary tend to alter the effective Q of two initially identical circuits

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[*] MS. accepted by the Editor, December, 1942.

and, as in the case of the phase discriminator, the values of primary and secondary inductances may require to be unequal. In analysing the conditions for unequal coupled circuits the author found that Beatty's curves could still be applied provided the abscissa scale was suitably chosen. Since completing the analysis it was discovered that work on similar lines had been reported in America[2], though full details of the method of solution were not given. It was therefore thought that the author's analysis and conclusions would prove helpful to those engaged upon the design of I.F. or R.F. coupled circuit filters with band-pass characteristics.

2. Generalised Selectivity Characteristics

Taking the normal type of mutual inductance-coupled tuned circuits and assuming only that the resonant frequencies of either circuit are equal when acting independently of the other, the circuit and its equivalents are shown in Figs. 1, 2 and 3. In Fig. 2 the valve is indicated as a constant current generator of $I = g_m Eg$ with its slope resistance, Ra, in parallel with C_1 and the input resistance, Rg, of the next valve in parallel with C_2. Ra and Rg have been included in the series resistances R_{T1} and R_{T2} of Fig. 3 so that

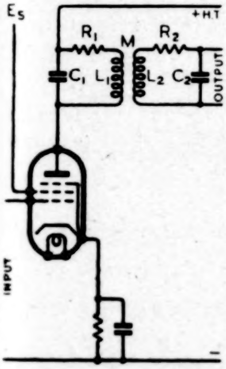

Fig. 1.—*Mutual inductance - coupled tuned circuits.*

$$R_{T1} = R_1 + \frac{(\omega L_1)^2}{Ra}$$

and

$$R_{T2} = R_2 + \frac{(\omega L_2)^2}{Rg}.$$

Analysing the network of Fig. 3 in terms of its impedances gives for the transfer impedance

$$Z_T = \frac{E_2}{I} = \frac{Z_1 Z_3 Z_5}{(Z_1 + Z_2 + Z_3)(Z_3 + Z_4 + Z_5) - Z_3^2} \quad \ldots \quad \ldots \quad (1)$$

It should be noted that $g_m Z_T$ represents the overall amplification of the stage, i.e., $\frac{E_2}{Eg}$

Now

$$Z_1 + Z_2 + Z_3 = R_{T1} + j\left(\omega L_1 - \frac{1}{\omega C_1}\right)$$

$$= R_{T1} + j\omega_m L_1\left(\frac{\omega}{\omega_m} - \frac{\omega_m}{\omega}\right)$$

for

$$\omega_m = \frac{1}{\sqrt{L_1 C_1}} = \frac{1}{\sqrt{L_2 C_2}} \quad \ldots \quad \ldots \quad (2)$$

But

$$\frac{\omega}{\omega_m} - \frac{\omega_m}{\omega} = \frac{f}{f_m} - \frac{f_m}{f} = \frac{(f - f_m)(f + f_m)}{f \cdot f_m}$$

Writing $f_m + \Delta f$ for f,

where Δf = the frequency off-tune from resonance,

$$\frac{\omega}{\omega_m} - \frac{\omega_m}{\omega} = \frac{2\Delta f(f_m + \frac{\Delta f}{2})}{f_m(f_m + \Delta f)} \simeq \frac{2\Delta f}{f_m} = F$$

for in most practical cases we may make the assumption that $\Delta f \ll f_m$. Thus

$$Z_1 + Z_2 + Z_3 = R_{T1}(1 + jQ_1 F) \qquad (3)$$

where Q_1 = the final Q of the primary circuit when not coupled to the secondary

$$= \frac{\omega_m L_1}{R_{T1}} = \frac{\omega_m L_1}{R_1 + \frac{(\omega_m L_1)^2}{R_a}} = \frac{\omega_m L_1}{R_1 + \frac{1}{(\omega_m C_1)^2 R_a}}.$$

Similarly

$$Z_3 + Z_4 + Z_5 = R_{T2}(1 + jQ_2 F)$$

$$Z_T = \frac{\dfrac{-jM}{\omega C_1 C_2 R_{T1} R_{T2}}}{(1 + jQ_1 F)(1 + jQ_2 F) + \dfrac{\omega^2 M^2}{R_{T1} \cdot R_{T2}}}$$

From 2. $\quad \ldots \quad \ldots \quad (4)$

$$\frac{M}{\omega C_1 C_2 R_{T1} R_{T2}}$$

$$= \frac{\omega_m}{\omega}\left[\frac{\omega_m{}^2 L_1{}^2}{R_{T1}} \cdot \frac{\omega_m L_2}{R_{T2}} \cdot \frac{M}{\sqrt{L_1 L_2}} \cdot \sqrt{\frac{L_2}{L_1}}\right]$$

$$= \frac{\omega_m}{\omega}\left[R_{D1} \cdot Q_2 k \sqrt{\frac{L_2}{L_1}}\right]$$

where $R_{D1} = \frac{\omega_m{}^2 L_1{}^2}{R_{T1}}$, the dynamic resistance of the primary, and $k = \frac{M}{\sqrt{L_1 L_2}}$ = coefficient of coupling.

An alternative expression is

$$\frac{\omega_m}{\omega}\sqrt{Q_1Q_2}\,k\,.\,\sqrt{Q_1Q_2}\,\omega_m L_1\sqrt{\frac{L_2}{L_1}}$$

$$=\frac{\omega_m}{\omega}\,.\,\sqrt{Q_1Q_2}\,k\,.\,\sqrt{R_{D1}\,.\,R_{D2}}$$

where $R_{D2}=\dfrac{\omega_m{}^2L_2{}^2}{R_{T2}}$, the dynamic resistance of the secondary

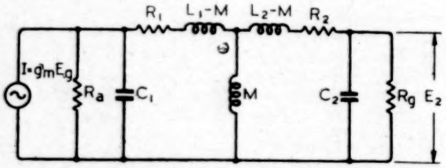

Fig. 2.—*The constant current valve generator with mutual inductance-coupled circuits.*

$$\frac{\omega^2M^2}{R_{T1}\,.\,R_{T2}}=\left[\frac{\text{Coupling reactance}}{\text{Geometric mean of total series resistances of primary and secondary circuits.}}\right]^2$$

$$=\left(\frac{\omega}{\omega_m}\right)^2\frac{\omega_mL_1}{R_{T1}}\cdot\frac{\omega_mL_2}{R_{T2}}\cdot\frac{M^2}{L_1L_2}=\left(\frac{\omega}{\omega_m}\right)^2Q_1Q_2k^2$$

Hence

$$Z_T=\frac{-j\dfrac{\omega_m}{\omega}R_{D1}Q_2k\sqrt{\dfrac{L_2}{L_1}}}{(1+jQ_1F)(1+jQ_2F)+Q_1Q_2k^2\dfrac{\omega^2}{\omega_m{}^2}}$$

$$=\frac{-j\dfrac{\omega_m}{\omega}R_{D1}Q_2k\sqrt{\dfrac{L_2}{L_1}}}{1+Q_1Q_2\left(k^2\dfrac{\omega^2}{\omega_m{}^2}-F^2\right)+j(Q_1+Q_2)F}\quad\dots\quad\dots\quad(5a)$$

or using the alternative expression for the numerator

$$Z_T=\frac{-j\dfrac{\omega_m}{\omega}\sqrt{Q_1Q_2}\,k\,\sqrt{R_{D1}\,.\,R_{D2}}}{1+Q_1Q_2\left(k^2\dfrac{\omega^2}{\omega_m{}^2}-F^2\right)+j(Q_1+Q_2)F}\quad\dots\quad\dots\quad(5b)$$

Rewriting Z_T as an amplitude and assuming that $\dfrac{\omega_m}{\omega}=1$

$$|Z_T|=\frac{R_{D1}Q_2k\sqrt{\dfrac{L_2}{L_1}}}{\sqrt{[1+Q_1Q_2(k^2-F^2)]^2+[(Q_1+Q_2)F]^2}}\quad\dots\quad\dots\quad(5c)$$

or

$$|Z_T|=\frac{\sqrt{Q_1Q_2}\,k\,\sqrt{R_{D1}\,.\,R_{D2}}}{\sqrt{[1+Q_1Q_2(k^2-F^2)]^2+[(Q_1+Q_2)F]^2}}\quad\dots\quad\dots\quad(5d)$$

Differentiating (5d) with respect to F and equating to 0 gives

$$F(\max Z_T)=\pm\sqrt{k^2-\frac{1}{2}\left(\frac{1}{Q_1{}^2}+\frac{1}{Q_2{}^2}\right)}$$

and replacing F in (5d)

$$|Z_T|_{\max}=\frac{\sqrt{R_{D1}\,.\,R_{D2}}\sqrt{Q_1Q_2}\,k}{\sqrt{1-\dfrac{[Q_1{}^2+Q_2{}^2]^2}{4Q_1{}^2Q_2{}^2}+(Q_1+Q_2)^2k^2}}\quad\dots\quad\dots\quad(6)$$

The relative voltage output is the ratio of expression (5d) to (6).

i.e.

$$\frac{|Z_T|}{|Z_T|_{\max}}=\sqrt{\frac{-\dfrac{[Q_1{}^2-Q_2{}^2]^2}{4Q_1{}^2Q_2{}^2}+(Q_1+Q_2)^2k^2}{[1+Q_1Q_2(k^2-F^2)]^2+[(Q_1+Q_2)F]^2}}$$

$$=\sqrt{\frac{\dfrac{(1+n)^2}{n}Q_1Q_2k^2-\dfrac{(1-n^2)^2}{4n^2}}{[1+Q_1Q_2(k^2-F^2)]^2+\dfrac{(1+n)^2}{n}Q_1Q_2F^2}}\quad\dots\quad\dots\quad(7a)$$

when $Q_2=nQ_1$.

It may be noted that the relative voltage output is independent of the ratio of $\dfrac{L_2}{L_1}$, the value of which affects only the overall amplification of the stage except insofar as R_{T2}, i.e., Q_2, is affected by L_2.

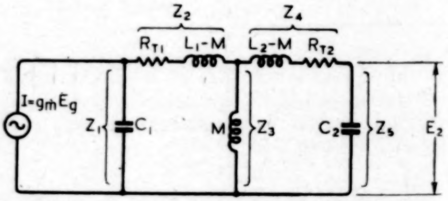

Fig. 3.—*A simplified equivalent circuit for Fig. 2.*

For $n=1$

$$\frac{|Z_T|}{|Z_T|_{\max}}=\frac{2Qk}{\sqrt{[1+Q^2(k^2-F^2)]^2+4Q^2F^2}}\quad\dots\quad\dots\quad(8a)$$

or replacing QF by α and Qk by β

$$\frac{|Z_T|}{|Z_T|_{\max}} = \frac{2\beta}{\sqrt{(1 + \beta^2 - \alpha^2)^2 + 4\alpha^2}} \qquad \text{(8b)}$$

which is identical with expression 28 (p. 551) of Beatty's article. He shows that by plotting the expression against α (Fig. 14, p. 551) to a logarithmic scale, the α scale can be converted to off-tune frequency Δf by suitably locating a similar logarithmic scale underneath. The registering point is usually taken at $\alpha = 1$, when $\Delta f_1 = \dfrac{fm}{2Q}$; for example if $f_m = 465$ kc/s and $Q = 116.25$, $\Delta f_1 = 2$ kc/s is located beneath $\alpha = 1$ and the frequency response for any particular value of β (Qk) may be read directly.

Expression (8b) may be rewritten to emphasise its dependence on α as follows :

$$\frac{|Z_T|}{|Z_T|_{\max}} = \frac{2\beta}{\sqrt{(1 + \beta^2)^2 + \alpha^2(2 - 2\beta^2) + \alpha^4}} \quad \dots \quad \dots \quad \text{(8c)}$$

and expression (7a) as

$$\frac{|Z_T|}{|Z_T|_{\max}} = \sqrt{\frac{\dfrac{(1+n)^2}{n}\beta_1^2 - \dfrac{(1-n^2)^2}{4n^2}}{(1+\beta_1^2)^2 + \alpha_1^2\left[\dfrac{1+n^2}{n} - 2\beta_1^2\right] + \alpha_1^4}} \quad \dots \quad \dots \quad \text{(7b)}$$

where

$$\beta_1 = \sqrt{Q_1Q_2}\,k \quad \text{and} \quad \alpha_1 = \sqrt{Q_1Q_2}\,F$$

Since α is drawn to a logarithmic scale it is clear that Beatty's curves will be applicable to expression (7b) provided there is complete identity with expression (8c) for all values of $\alpha_1 = m\alpha$, where m is a constant for a given value of n. The factor m can be included since it only involves the movement of the α_1 scale with respect to α by a constant amount because

$$\log \alpha_1 = \log \alpha + \log m$$

Replacing α_1 in expression (7b) by $m\alpha$, three equations are derived for complete identity between (8c) and (7b); the constant terms and the terms multiplying α^2 and α^4 must all be equal. Thus

$$\frac{(2\beta)^2}{(1+\beta^2)^2} = \frac{\dfrac{(1+n)^2}{n}\beta_1^2 - \dfrac{(1-n^2)^2}{4n^2}}{(1+\beta_1^2)^2} \quad \dots \quad \dots \quad \text{(9a)}$$

$$\frac{(2\beta)^2}{2 - 2\beta^2} = \frac{\dfrac{(1+n)^2}{n}\beta_1^2 - \dfrac{(1-n^2)^2}{4n^2}}{\left[\dfrac{1+n^2}{n} - 2\beta_1^2\right]m^2} \quad \dots \quad \dots \quad \text{(9b)}$$

$$4\beta^2 = \frac{\dfrac{(1+n)^2}{n}\beta_1^2 - \dfrac{(1-n^2)^2}{4n^2}}{m^4} \quad \dots \quad \text{(9c)}$$

Solving (9a) for β_1 gives

$$\beta_1 = \sqrt{\frac{(1+n)^2(1+\beta^2)}{4n} - 1} \quad \dots \quad \text{(10)}$$

Solving (9c) for m and replacing β_1 by its value from (10).

$$m = \sqrt[4]{\frac{\dfrac{(1+n)^2}{n}\beta_1^2 - \dfrac{(1-n^2)^2}{4n^2}}{4\beta^2}} = \frac{1+n}{2\sqrt{n}} \quad \dots \quad \dots \quad \text{(11)}$$

and solving (9b) gives the same value for m thus proving that there is complete identity between expressions (7b) and (8c) for all values of α when $\alpha_1 = m\alpha$. Beatty's original curves are therefore applicable to the more general case of unequal coupled circuits having mutual inductance coupling. A series of curves is plotted in Fig. 4 from expression (10) connecting β_1 $(\sqrt{Q_1Q_2}\,k)$ and $n\dfrac{(Q_2)}{Q_1}$ for selected values of β, and these may be used in conjunction with Fig. 5 for determining the frequency response of any

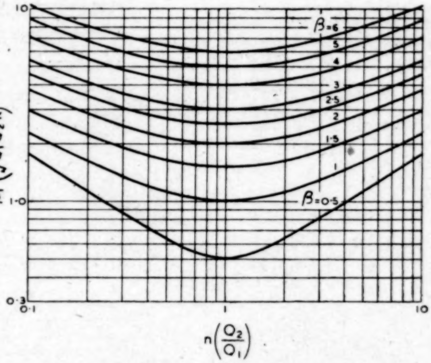

Fig. 4.—*The relationship between* β_1 $(\sqrt{Q_1Q_2}\,k)$ *and* $n\left(\dfrac{Q_2}{Q_1}\right)$ *for selected values of* $\beta(Qk)$.

particular pair of coupled circuits. It will be noted that the curves are symmetrical about $n = 1$ since

$$\beta_1 = \sqrt{\frac{1+n^2}{4n}(1+\beta^2) + \frac{1+\beta^2}{2} - 1}$$

$$= \frac{1}{2}\sqrt{\left(n+\frac{1}{n}\right)\left(1+\beta^2\right) + 2\left(\beta^2 - 1\right)}$$

and n is plotted to a logarithmic scale.

Selectivity or frequency response is more conveniently expressed in decibels than in relative voltage ratio and expression (7b) then becomes

$$\text{Loss (db.)} = 20 \log_{10} \sqrt{\frac{(1+\beta_1^2)^2 + \alpha_1^2\left(\frac{1+n^2}{n} - 2\beta_1^2\right) + \alpha_1^4}{\frac{(1+n)^2}{n}\beta_1^2 - \frac{(1-n^2)^2}{4n^2}}} \quad \ldots \quad \ldots \quad 12$$

where reference level, 0 db., is the voltage obtained at $|Z_T| = |Z_T|_{\max}$. This is plotted in Fig. 5 against $\frac{\alpha_1}{m}$, i.e., $\frac{2\sqrt{n}}{1+n}\sqrt{Q_1Q_2}\,F$ for selected values of β_1 satisfying equation (10) for the same values of β as are used for Fig. 4.

To illustrate the use of the curves consider the frequency response of a pair of coupled circuits having the following component values.

$f_m = 465$ kc/s, $Q_{10} = 150 = Q_{20}$

$L_1 = 300\ \mu$H, $L_2 = 400\ \mu$H,

$R_a = 1\text{M}\Omega$ $R_g = 0.5\ \text{M}\Omega$

$M = 5{\cdot}75\ \mu$H,

$$R_{r1} = \frac{\omega_m L_1}{Q_{10}} + \frac{\omega_m^2 L_1^2}{R_a} = 5{\cdot}83 + 0{\cdot}768 = 6{\cdot}598\Omega$$

$$Q_1 = \frac{Q_{10}R_1}{R_{r1}} = \frac{150 \times 5.83}{6.598} = 133$$

Similarly $R_{r2} = 7{\cdot}78 + 2{\cdot}73 = 10{\cdot}51\Omega$

and $$Q_2 = \frac{Q_{20}R_2}{R_{r2}} = \frac{150 \times 7{\cdot}78}{10{\cdot}51} = 111$$

$$n = \frac{Q_2}{Q_1} = 0{\cdot}835$$

$$\beta_1 = \sqrt{Q_1Q_2}\,k = 2{\cdot}02$$

Referring to Fig. 4, it is seen that $n = 0{\cdot}835$, $\beta_1 = 2{\cdot}02$ is a point on the curve for $\beta = 2$, i.e., the reference curve for frequency response on Fig. 5 is the fourth from the left.

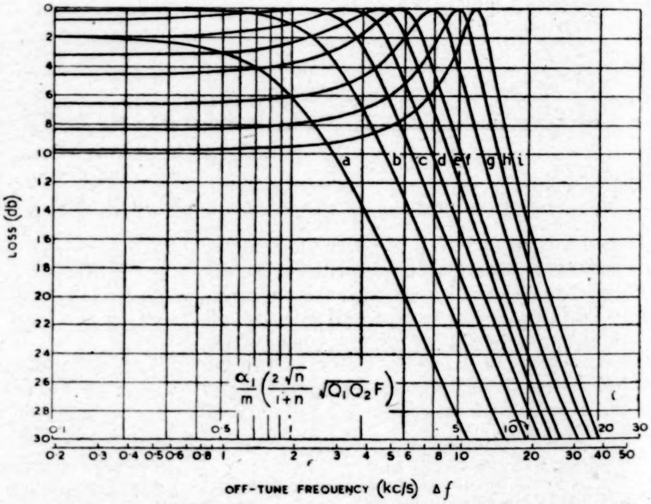

Fig. 5.—*Generalised selectivity curves for tuned coupled circuits.*

$n = \frac{Q_2}{Q_1}$, $m = \frac{1+n}{2\sqrt{n}}$,

(*a*) $\beta(Qk) = 0.5$, $\sqrt{Q_1Q_2}\,k = \frac{1}{2}\sqrt{\frac{1.25(n^2+1)}{n} - 1.5}$

(*b*) $\beta(Qk) = 1$, $\sqrt{Q_1Q_2}\,k = \sqrt{\frac{n^2+1}{2n}}$

(*c*) $\beta(Qk) = 1.5$, $\sqrt{Q_1Q_2}\,k = \frac{1}{2}\sqrt{\frac{3.25(n^2+1)}{n} + 2.5}$

(*d*) $\beta(Qk) = 2$, $\sqrt{Q_1Q_2}\,\text{k} = \frac{1}{2}\sqrt{\frac{5(n^2+1)}{n} + 6}$

(*e*) $\beta(Qk) = 2.5$, $\sqrt{Q_1Q_2}\,k = \frac{1}{2}\sqrt{\frac{7.25(n^2+1)}{n} + 10.5}$

(*f*) $\beta(Qk) = 3$, $\sqrt{Q_1Q_2}\,\text{k} = \frac{1}{2}\sqrt{\frac{10(n^2+1)}{n} + 16}$

(*g*) $\beta(Qk) = 4$, $\sqrt{Q_1Q_2}\,k = \frac{1}{2}\sqrt{\frac{17(n^2+1)}{n} + 30}$

(*h*) $\beta(Qk) = 5$, $\sqrt{Q_1Q_2}\,k = \frac{1}{2}\sqrt{\frac{26(n^2+1)}{n} + 48}$

(*i*) $\beta(Qk) = 6$, $\sqrt{Q_1Q_2}\,k = \frac{1}{2}\sqrt{\frac{37(n^2+1)}{n} + 70}$

The off-tune frequency scale is located underneath the $\frac{\alpha_1}{m}$ scale such that

$$\Delta f' = \frac{(1+n)\ f_m}{4\sqrt{n}\ \sqrt{Q_1Q_2}} = 1{\cdot}92 \text{ kc/s} \ldots \quad (13)$$

registers with $\frac{\alpha_1}{m} = 1$ as shown in Fig. 5, and the losses at 5, 10, and 20 kc/s off-tune are therefore 3, 15.5 and 28.4 db. respectively.

3. Generalised E_2E_g Phase Shift Curves

The phase angle between the secondary voltage E_2 and the input current I is obtained by rationalising (5b). Thus the phase angle

$$\phi = \tan^{-1}\frac{-(1 + Q_1Q_2(k^2 - F^2))}{-(Q_1 + Q_2)F}$$

$$= \tan^{-1}\frac{-(1 + \beta_1^2 - \alpha_1^2)}{\frac{-(1+n)}{\sqrt{n}}\alpha_1} \qquad (14)$$

The minus sign in numerator and denominator shows that when $\alpha_1 = 0$, i.e., $\Delta f = 0$, the phase angle is 270° and it changes through 180° to 90° at $\alpha_1 = +\infty$. If the connections to the primary or secondary coils are reversed, the mutual inductance coupling becomes negative and expression (5b) is prefixed by a negative sign. This changes the sign of numerator and denominator in expression

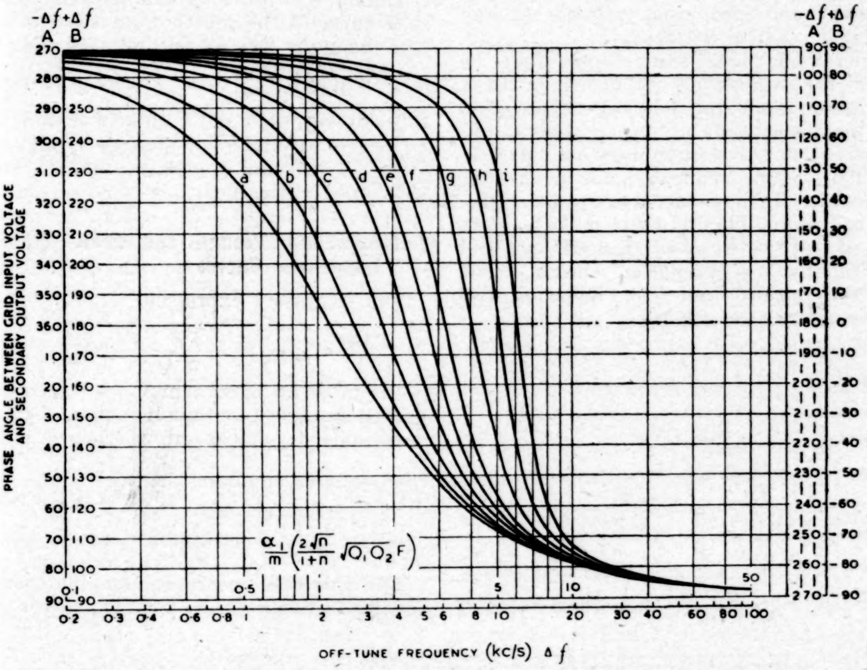

Fig. 6.—*Generalised phase-shift curves for tuned coupled circuits. Left-hand vertical scale used for inductance and positive mutual inductance couplings. Right-hand vertical scale used for capacitance and negative mutual inductance couplings. For negative off-tune frequencies use the A scales and for positive off-tune frequencies use the B scales.*

(a) $\beta(Qk) = 0.5,\ \sqrt{Q_1Q_2}\,k = \frac{1}{2}\sqrt{\frac{1.25(n^2+1)}{n} - 1.5}$

(b) $\beta(Qk) = 1,\ \sqrt{Q_1Q_2}\,k = \sqrt{\frac{n^2+1}{2n}}$

(c) $\beta(Qk) = 1.5,\ \sqrt{Q_1Q_2}\,k = \frac{1}{2}\sqrt{\frac{3.25(n^2+1)}{n} + 2.5}$

(d) $\beta(Qk) = 2,\ \sqrt{Q_1Q_2}\,k = \frac{1}{2}\sqrt{\frac{5(n^2+1)}{n} + 6}$

(e) $\beta(Qk) = 2.5,\ \sqrt{Q_1Q_2}\,k = \frac{1}{2}\sqrt{\frac{7.25(n^2+1)}{n} + 10.5}$

(f) $\beta(Qk) = 3,\ \sqrt{Q_1Q_2}\,k = \frac{1}{2}\sqrt{\frac{10(n^2+1)}{n} + 16}$

(g) $\beta(Qk) = 4,\ \sqrt{Q_1Q_2}\,k = \frac{1}{2}\sqrt{\frac{17(n^2+1)}{n} + 30}$

(h) $\beta(Qk) = 5,\ \sqrt{Q_1Q_2}\,k = \frac{1}{2}\sqrt{\frac{26(n^2+1)}{n} + 48}$

(i) $\beta(Qk) = 6,\ \sqrt{Q_1Q_2}\,k = \frac{1}{2}\sqrt{\frac{37(n^2+1)}{n} + 70}$

14 to positive so that for negative mutual inductance $\phi = 90^\circ$ at $\alpha_1 = 0$ and changes through 0° to -90° at $\alpha_1 = +\infty$

When $n = 1$, expression (14) becomes

$$\phi = \tan^{-1}\frac{-(1 + \beta^2 - \alpha^2)}{-2\alpha} \quad \ldots \quad (15)$$

The input current I is in phase with the grid input voltage E_g so that ϕ represents the overall phase shift between the output secondary and grid input voltages at any particular off-tune frequency.

Generalised phase shift curves may be drawn for expression (15) against α to a logarithmic scale for selected values of β and the phase shift at any particular off-tune frequency is read by locating correctly a similar off-tune frequency scale underneath the α scale. If these curves are to be applicable to unequal circuits there must be complete identity between expressions (14) and (15) for all values of α and α_1 when $\alpha_1 = m\alpha$ and this means that the following two equations must be satisfied

$$\frac{-m}{\dfrac{1+n}{\sqrt{n}}} = \frac{-1}{2}$$

i.e.

$$m = \frac{1+n}{2\sqrt{n}} \quad \ldots \quad \ldots \quad (16)$$

and

$$\frac{1 + \beta_1^2}{\left(\dfrac{1+n}{\sqrt{n}}\right)m} = \frac{1+\beta^2}{2}$$

or

$$\beta_1 = \sqrt{\frac{(1+n)^2}{4n}(1+\beta^2) - 1} \quad (17)$$

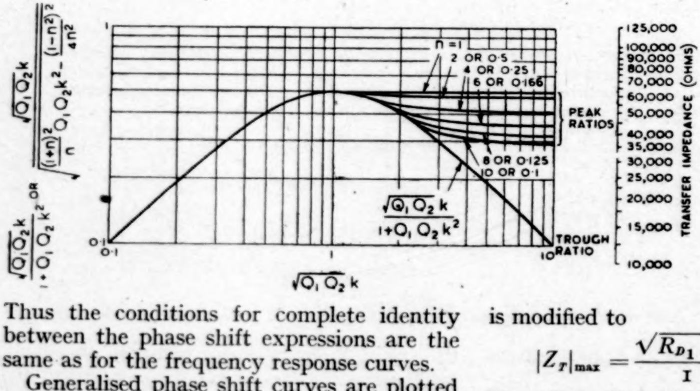

Fig. 7.—*The ratio of peak and trough transfer impedances to the geometric mean of primary and secondary dynamic resistances.*

Thus the conditions for complete identity between the phase shift expressions are the same as for the frequency response curves.

Generalised phase shift curves are plotted in Fig. 6 against $\dfrac{\alpha_1}{m}$ to a logarithmic scale for the same selected values of β_1 as those used for Fig. 5. When Δf is negative, i.e., the frequency is less than the mid frequency fm, the left-hand vertical A scale of Fig. 6, from 270° at $\Delta f = 0$ through 360° to $+90^\circ$ at $\Delta f = -\infty$ is used for positive M, whilst for negative M it is the right-hand vertical scale A from $+90^\circ$ through 180° to 270° at $\Delta f = -\infty$.

Taking the previous example the phase shift curve is the fourth from the left and 1.92 kc/s on the logarithmic Δf scale is registered with $\dfrac{\alpha_1}{m} = 1$; hence the phase shifts at -5, -10 and -20 kc/s off-tune are $+19^\circ$, $+64^\circ$ and $+78.5^\circ$ respectively, and at $+5$, $+10$ and $+20$ kc/s are 161°, 116°, and 101.5° respectively.

4. Generalised Trough and Peak Transfer Impedance Curves

The frequency expression

$$F = \pm\sqrt{k^2 - \frac{1}{2}\left(\frac{1}{Q_1^2} + \frac{1}{Q_2^2}\right)}$$

given above for maximum Z_T, i.e., maximum overall amplification, involves three separate conditions dependent on whether k is less than, equal to, or greater than $\sqrt{\dfrac{1}{2}\left(\dfrac{1}{Q_1^2} + \dfrac{1}{Q_2^2}\right)}$.

$$(1)\ k < \sqrt{\frac{1}{2}\left(\frac{1}{Q_1^2} + \frac{1}{Q_2^2}\right)}$$

For this case maximum amplification is obtained when $F = 0$ so that expression (5d) is modified to

$$|Z_T|_{\max} = \frac{\sqrt{R_{D1} \,.\, R_{D2}}\ \sqrt{Q_1Q_2}\,k}{1 + Q_1Q_2k^2} \quad \ldots \quad (18)$$

The effect of varying the coupling coefficient is shown by the symmetrical curve in Fig. 7, where $\frac{\sqrt{Q_1Q_2}\,k}{1 + Q_1Q_2k^2}$ is plotted against $\sqrt{Q_1Q_2}\,k$, both to a logarithmic scale. The advantage of this is that by adjusting a similar logarithmic scale, marked in ohms, such that $\sqrt{R_{D_1}R_{D_2}}$ ohms registers with $\frac{\sqrt{Q_1Q_2}\,k}{1 + Q_1Q_2k^2} = 1$, the transfer impedance for any particular value of $\sqrt{Q_1Q_2}\,k$ can be read directly. Multiplication of the transfer impedance by g_m gives the overall amplification of the stage. For the previous example the value of $|Z_T|_{\max}$ can be read directly by registering 123,000 Ω with $\frac{\sqrt{Q_1Q_2}\,k}{1 + Q_1Q_2k^2} = 1$ as shown by the scale to the right of Fig. 7. The maximum value of $|Z_T|_{\max}$ occurs at $\sqrt{Q_1Q_2}\,k = 1$ and for couplings exceeding this it falls except when $Q_2 = Q_1$. The symmetrical curve actually represents the value of $|Z_T|$ at $f = f_m$, so that above a certain value of $\sqrt{Q_1Q_2}\,k$ (the value is $\sqrt{\frac{1}{2}\left(\frac{1}{Q_1^2} + \frac{1}{Q_2^2}\right)}$) it represents the trough transfer impedance because the frequency response becomes double peaked.

(2) $k = \sqrt{\frac{1}{2}\left(\frac{1}{Q_1^2} + \frac{1}{Q_2^2}\right)}$

This value represents critical coupling and maximum $|Z_T|$ occurs at $f = f_m$, but for greater values, maximum is obtained at some off-tune frequency. The value of $\sqrt{Q_1Q_2}k$ at which critical coupling is realised is a function of $n\left(\frac{Q_2}{Q_1}\right)$ and is

$$\sqrt{Q_1Q_2}\,k = \sqrt{\frac{1}{2}\cdot\frac{1 + n^2}{n}} \quad \cdots \quad \cdots \quad (19)$$

i.e., it increases as n is increased. When $n = 1$, $Qk = 1$ so that critical coupling and maximum $|Z_T|$ coincide, but for all other values of n, critical coupling requires $\sqrt{Q_1Q_2}\,k$ to be greater than 1. It may be noted that $\sqrt{Q_1Q_2}\,k$ for critical coupling is the same for $n = A$ as for $n = \frac{1}{A}$.

(3) $k > \sqrt{\frac{1}{2}\left(\frac{1}{Q_1^2} + \frac{1}{Q_2^2}\right)}$

For couplings exceeding $\sqrt{\frac{1}{2}\left(\frac{1}{Q_1^2} + \frac{1}{Q_2^2}\right)}$ double peaked frequency response is obtained, the peaks occurring at off-tune frequencies corresponding to

$$\Delta f = \pm\frac{f_m}{2}\sqrt{k^2 - \frac{1}{2}\left(\frac{1}{Q_1^2} + \frac{1}{Q_2^2}\right)}$$

As k is increased the off-tune frequency increases but $|Z_T|_{\max}$ decreases except when $n = 1$. From expression (6)

$$|Z_T|_{\max} = \frac{\sqrt{R_{D_1}\,.\,R_{D_2}}\,.\,\sqrt{Q_1Q_2}\,k}{\sqrt{1 - \frac{(Q_1^2 + Q_2^2)^2}{4Q_1^2Q_2^2} + (Q_1 + Q_2)^2k^2}}$$

$$|Z_T|_{\max} = \sqrt{R_{D_1}\,.\,R_{D_2}}\,\frac{\sqrt{Q_1Q_2}\,k}{\sqrt{\frac{(1+n)^2}{n}Q_1Q_2\,k^2 - \frac{(1-n^2)^2}{4n^2}}}$$

The factor $\frac{\sqrt{Q_1Q_2}\,k}{\sqrt{\frac{(1+n)^2}{n}Q_1Q_2\,k^2 - \frac{(1-n^2)^2}{4n^2}}}$ is plotted in Fig. 7 against $\sqrt{Q_1Q_2}\,k$ for $n = 1$ to 10, and it represents the value of transfer impedance at the peak of the frequency response. Each curve joins the symmetrical curve at $\sqrt{Q_1Q_2}\,k = \sqrt{\frac{1}{2}\frac{(1+n)^2}{n}}$ (critical coupling) and, as $\sqrt{Q_1Q_2}\,k$ increases, becomes asymptotic to $\frac{\sqrt{n}}{n+1}$. The curve for $n = A$ is the same as for $n = \frac{1}{A}$. The value of peak transfer impedance for any particular example is read directly by registering $\sqrt{R_{D_1}R_{D_2}}$ with $\frac{\sqrt{Q_1Q_2}\,k}{1 + Q_1Q_2\,k^2} = 1$ as shown to the right of Fig. 7.

The greatest ratio change of $|Z_T|$ from its maximum value for $n = 10$ is only 0.58 to 1 representing a loss of 4.75 db. whilst for more practical values of n between 0.5 and 2 it does not exceed 0.5 db. and may generally be neglected.

5. Maximum Transfer Impedance for a given Selectivity Characteristic

It is possible to vary the ratio of $\frac{L_2}{L_1}$ and $\frac{Q_2}{Q_1}$ and at the same time retain constant selectivity. The variation of $\frac{L_2}{L_1}$ and $\frac{Q_2}{Q_1}$ does, however, affect the maximum transfer impedance, and ratios can be found to give the maximum value of this.

Referring to Fig. 5 it is seen that selectivity is determined by $\sqrt{Q_1Q_2}\,k$ and $\frac{2\sqrt{n}}{1+n}\sqrt{Q_1Q_2}\,F$. The first parameter affects the actual curve to be used whilst the latter fixes the horizontal frequency scale. Selectivity is therefore unaffected by variations of Q_2 and Q_1 if the following conditions are fulfilled.

Firstly that $\sqrt{Q_1Q_2}\,k$ is a specified function of n. In the example cited above, the curve is the fourth from the left so that k must be chosen to satisfy

$$\sqrt{Q_1Q_2}\,k = \frac{1}{2}\sqrt{\frac{5(n^2+1)}{n}+6}$$

This involves no difficulties, for any values of Q_1 and Q_2 can be selected and k adjusted accordingly.

Secondly that $\frac{2\sqrt{n}}{1+n}\sqrt{Q_1Q_2}$ is a constant.

Since the maximum value of $|Z_T|_{\max}$ at $\sqrt{Q_1Q_2}\,k = 1$ is $\frac{1}{2}\sqrt{R_{D1}R_{D2}}$ (see expression (18)) it follows that it is realised by making R_{D1} and R_{D2} as large as possible.

Now

$$R_{D1} = \frac{R_{D10} \cdot R_a}{R_{D10} + R_a}$$

where $R_{D10} = \omega L_1 Q_{10}$, the dynamic resistance of the undamped primary circuit, and Q_{10} = the magnification of the undamped primary.

R_{D1} for a fixed value of R_a, is clearly greatest when R_{D10} is greatest, i.e., when L_1 and Q_{10} are as large as possible. Maximum value of Q_{10} is determined by practical considerations so that the value of R_{D1} is finally determined by L_1 and R_a.

But

$$Q_1 = \frac{\omega_m L_1}{R_1 + \frac{(\omega_m L_1)^2}{R_a}} = \frac{Q_{10}}{1 + Q_{10} \cdot \frac{\omega_m L_1}{R_a}}$$

i.e., $$L_1 = \frac{Q_{10} - Q_1}{Q_{10}Q_1} \cdot \frac{R_a}{\omega} \quad \ldots \quad \ldots \text{(21a)}$$

and $$L_2 = \frac{Q_{20} - Q_2}{Q_{20} \cdot Q_2}\,\frac{R_g}{\omega} \quad \ldots \quad \ldots \text{(21b)}$$

For constant selectivity

$$\frac{\sqrt{n}}{1+n}\sqrt{Q_1Q_2} = \text{constant} = B$$

By noting that $n = \frac{Q_2}{Q_1}$ and solving the above for Q_2

$$Q_2 = \frac{BQ_1}{2Q_1 - B} \quad \ldots \quad \ldots \text{(22)}$$

Now maximum

$$|Z_T|_{\max} = \tfrac{1}{2}\sqrt{R_{D1} \cdot R_{D2}}$$
$$= \tfrac{1}{2}\sqrt{\omega_m L_1 Q_1 \cdot \omega_m L_2 Q_2}$$

Replacing L_1, L_2 and Q_2 by expressions (21a), (21b) and (22) and assuming that $Q_{10} = Q_{20} = Q_0$,

Maximum $|Z_T|_{\max}$

$$= \frac{1}{2}\sqrt{\left(Q_0 - Q_1\right)\left(Q_0 - \frac{BQ_1}{2Q_1 - B}\right)\frac{R_aR_g}{Q_0^2}} \quad \ldots \quad \ldots \text{(23)}$$

Differentiating (23) with respect to Q_1 and equating to 0 gives $Q_1 = B$ and combining this with expression (22).

$$Q_2 = B$$

From (21a) and (21b)

$$L_1 = \frac{Q_0 - B}{BQ_0}\,\frac{R_a}{\omega}$$

$$L_2 = \frac{Q_0 - B}{BQ_0}\,\frac{R_g}{\omega}$$

or $$\frac{L_2}{L_1} = \frac{R_g}{R_a}$$

Hence for maximum value of maximum transfer impedance the important fact is established that Q_1 should equal Q_2 and the ratio of L_2 to L_1 should be that of the secondary to primary external damping resistances.

The values of L_2 and L_1 giving maximum amplification may not always be realisable in practice as stray and valve capacitances set a limit to the minimum tuning capacitance. Under these conditions the maximum value of L_2 and L_1 permissible with the particular minimum value of tuning capacitance should be chosen and extra damping added if necessary to give the required selectivity characteristic.

(*To be concluded.*)

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The Quartz Crystal Gate and the Introduction of Highly Selective Circuits

To the Editor, "Wireless Engineer"

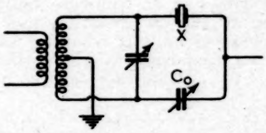
SIR,—In the April issue of *Wireless Engineer*, there appears an article by Builder and Benson on "Simple Quartz Crystal Filters of Variable Band Width."[1] This article was written on the assumption, which I believe is the general view, that the highly-selective quartz crystal receivers, which are now coming into wide application, are based on a circuit which was proposed by me in 1929, and which is generally known as the Quartz Crystal Gate. The article having previously been published in *A.W.A. Technical Review*,[2] the authors received some comment from engineers of the Bell Laboratories, with the result that they state in an appendix that after all I was probably not the originator of this circuit, but that I was preceded by Marrison, who applied for a U.S. Patent in 1927 on the use of a quartz crystal.[3]

It is not surprising that the general opinion should be established that I am the person to whom credit should be given for the introduction of the quartz crystal for highly selective reception, for the scientific world generally did not hear of Marrison's work until 1935, when his Patent was published, eight years after his date of application. In the meantime, my Patents [4], [5], [6], [7], on the use of quartz crystals had been applied for in 1929 and had been granted in England, some of them also being granted in U.S.A., and other countries. It is well known that I did not wait until my Patents had been accepted before publishing the circuits and their application in the technical press. My colleagues and I realised immediately that these circuits had some valuable properties and we gave public demonstrations of the highly selective circuits from 1929 onwards, the highly selective device employed being the quartz crystal.

After numerous demonstrations of the performance of the highly selective quartz crystal, I published an article in *Radio News* in 1931[8], giving details of the circuits. At that time I was certainly unaware of the existence of the Marrison patent of the Bell Laboratories, and as far as I know, no effort was made by them to make their work known for some years after this.

There was ample opportunity for the Bell Laboratories to make their work known had they wished to do so, and it has always been a mystery to me why they did not do so in the period from 1930 to 1932. I would certainly have welcomed their assistance at that time, when I was doing my utmost to convince the scientific world that highly selective circuits such as the quartz crystal are really valuable. Thus the facts stand out :—

(1) That the crystal gate circuit was made known to the scientific world by me in 1929.



(2) That much discussion took place for about three years in the technical press on the use of highly selective circuits in general and on quartz crystals in particular.

(3) That the scientific world in general had no knowledge of Marrison's patent until 1935.

There is now the question as to whether Marrison did actually describe the operation of the quartz crystal in the manner in which it has come into general use. His U.S. Patent Specification certainly does not do so. The quartz crystal gate which is in use to-day, and which was described by me in 1929 is shown in the Figure. Here X is a quartz crystal and C_0 is a variable condenser which can be varied to eliminate or cut down certain interference wherever this might appear in the desired frequency band. For example the quartz crystal can receive modulated waves, and in 1929 I actually demonstrated the reception of broadcast programmes on a quartz crystal where modulation frequencies up to 5,000 c/s were employed. Actually this fact was surprising to the scientific world in general, as it had been supposed that a quartz crystal was so very selective that it would receive only the carrier frequency and would cut off all the side frequencies. One of the principles which I put forward at that time was that no matter how selective a circuit or device might be, it does allow a band of frequencies to be received, but in such a manner that the response for any frequency is inversely proportional to the separation from the resonance frequency. Once this fact was recognised it became possible to employ tone correction to give faithful response of modulated waves. This was known as the Stenode principle and was demonstrated in 1929 using a quartz crystal as the selective device.

The function of the variable condenser C_0 was to eliminate any interfering waves of a definite frequency or to cut down interference over a fraction of the operating wave band. No reference to this feature appears in Marrison's patent. What Marrison does is to employ a condenser to neutralise the inherent capacitance of the quartz crystal and its holder. His whole specification is based on the belief that because of the extreme selectivity of the crystal, only a very narrow band of frequencies can be usefully employed. For instance, frequencies about 200 c/s distant from the resonant frequency will be so attenuated as to be of little or no use, but all the same the crystal might be employed for such a very narrow frequency band. However, owing to the inherent capacitance of the crystal and its holder, this narrow filter might be vitiated by capacitance effects and it became necessary for Marrison to eliminate this inherent capacitance in order to make the filter useful as a filter for a narrow band of frequencies. Thus he neutralised the inherent capacitance of the crystal and its holder but he did not describe how to eliminate the other interference, and in fact, on his assumption that under any circumstances nothing whatever can pass the crystal if its frequency is appreciably different from that of the crystal, there was no need for him to do so.

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[1] Builder & Benson, *Wireless Engineer*, April 1943, p. 183.

[2] Builder & Benson, *A.W.A. Technical Review*, 1941, Vol. 5, No. 3, p. 93.

[3] Marrison, U.S. Patent 1994658, filed June 7th, 1927, granted March 19th, 1935.

[4] J. Robinson, Brit. Patent 337049, application July 26, 1929, granted October 27th, 1930.

[5] J. Robinson, Brit. Patent 337050, application July 26th, 1929, accepted October 27th, 1930.

[6] J. Robinson, Brit. Patent 344869, application September 9th, 1929, accepted March 9th, 1931.

[7] J. Robinson, Brit. Patent 344034, application November 28th, 1929, accepted March 2nd, 1931.

[8] J. Robinson, *Radio News*, Vol. 12, p. 682.

In the wide application which is made of the quartz crystal gate for selective reception, the balancing condenser is generally adjusted in order to give the utmost freedom from interfering waves, and thus it is employed in the method described by me. It is not employed according to Marrison's method when the balancing condenser is adjusted once for all. J. ROBINSON.

Mill Hill, London, N.W.7.

"Chart for Radio Noise"

To the Editor, "Wireless Engineer"

SIR,—I should like to comment on Mr. Sowerby's "Chart for Radio Noise" which appeared in the issue for July, 1943. In equation (5) for the equivalent noise voltage $\bar{e}_{gs}$ at the grid, the factor $\left(\frac{R_L}{R_a} + 1\right)$ should be omitted giving

$$\bar{e}_{gs} = F \frac{\sqrt{2I_a\epsilon \,.\, \Delta f}}{g_m}$$

The error arose from the fact that $\bar{\imath}_s$ is the *short-circuit* noise current and thus the noise voltage $\bar{e}_s$ across the anode load is $\bar{\imath}_s R_a R_L/(R_L + R_a)$ and not $\bar{\imath}_s R_L$ as stated. Thus in using the Chart the point $R_L/R_a = 0$ should always be used.

In calculating the valve noise from equation (3) the chief uncertainty arises in estimating the smoothing factor F. It is therefore useful to note that Thompson, North and Harris have published an authoritative and comprehensive series of papers on the theoretical and experimental investigation of "Fluctuations in space-charge-limited currents at moderately high frequencies" which appeared in the *R.C.A. Review* between January 1940 and July 1941. R. E. BURGESS.

To the Editor, "Wireless Engineer."

SIR,—In reply to Mr. Burgess I should first like to thank him for calling attention to the useful references concerning the estimation of F.

With regard to equation (5), I must confess my error, and offer apologies. I had been led to believe that $\bar{\imath}_s$ was constant and in series with R_a and R_L resulting in (5). It appears [1] that this notion is not impossible, but the weight of experimental evidence is with Mr. Burgess.[2]

Salisbury. J. McG. SOWERBY.

"Optimum Conditions in Class A Amplifiers"

To the Editor, "Wireless Engineer"

SIR,—The methods adopted in your February Editorial, and in Dr. Bradshaw's letter (June) for finding the optimum conditions when anode dissipation is the limiting factor, would appear to involve a fair amount of labour.

In Nottingham's paper[3] the condition for maximum output was expressed in the form of a cubic equation, which may be written (using the notation of your Editorial) as :

$$P_{am}\, I_{min}/I_0^2 = 4r_a I_0 - 3r_a I_{min} + \epsilon$$

Nottingham suggested the solution of this equation by graphical or trial and error methods which would also involve a fair amount of labour. It is possible, however, to find an approximate, but very accurate analytical solution of this equation. In general $\epsilon - 3r_a I_{min}$ is small compared with $4r_a I_0$ so that a first approximation is

$$I_0 \doteqdot \sqrt[3]{P_{am}\, I_{min}/4r_a}$$

A second approximation may be found by writing the equation in the form

$$P_{am}\, I_{min}/4r_a I_0^3 = 1 - 3I_{min}/4I_0 + \epsilon/4r_a I_0$$

Taking the cube root of both sides, and expanding the R.H. side by the binomial theorem

$$\sqrt[3]{P_{am}\, I_{min}/4r_a}/I_0 \doteqdot 1 - I_{min}/4I_0 + \epsilon/12r_a I_0$$

$$\therefore \quad I_0 \doteqdot \sqrt[3]{P_{am}\, I_{min}/4r_a} + I_{min}/4 - \epsilon/12r_a$$

This formula will be found to be very accurate, and it enables I_0 to be obtained by slide rule calculation in a few seconds. For example, taking Dr. Bradshaw's figures $r_a = 1700$ ohms $\epsilon = 85$v $P_{am} = 20$w $I_{min} = 20$mA, the formula gives $I_0 = 40$ mA from which $V_{a0} = 500$ v. Also the optimum load resistance $R = 2r_a + V_{a0}/I_0$ (Nottingham) from which $R = 15900$ ohms $= 9.4\ r_a$ and the output power $= \frac{1}{2}R(I_0 - I_{min})^2 = 3.2$ W.

A. S. GLADWIN.

Research Laboratories
of the General Electric Co., England.

The Place of Scientists in the Community

SIR,—The suggestion made in the letter from Sir Robert Pickard, Professor Findlay and Sir Lawrence Bragg, published in the August issue of *Wireless Engineer*, that scientists who emphasise the possible achievements of a properly directed scientific effort after the war are liable to raise unjustifiable and dangerous hopes in the community, seems to us to be singularly unfortunate and ill-timed. In some details the prophets may be over-sanguine, but there can be no reasonable doubt but that benefits lie within our grasp which are vastly greater than those we enjoy at present. Exaggeration is unnecessary and to be deplored; but inspired vision, with the energy it can unleash, will be more valuable after the war than ever before. It is quite certain that unless scientific education and research are financed and staffed on a scale undreamed of in this country before the war, we shall fall far behind the U.S.A. and U.S.S.R. in technical advances in industry. The community will lose the advantages that should be gained from the great store of scientific ability in this country.

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[1] Moullin. Spontaneous fluctuations of voltage, p. 226.

[2] p. 224.

[3] *Proc. I.R.E.*, Vol. 29, p. 622, 1941.

What is said and written at the present time with respect to scientists and administration is deeply coloured by the ridiculous position in which scientists find themselves to-day. It is almost true to say that they have no executive authority at all, even in fields entirely scientific. We are not suggesting that there should be a monopoly in administration for scientists, but only equality with those trained as classicists and historians. There is no reason to suppose that scientists are peculiarly lacking in those gifts which are required by a good administrator.

It must be conceded that generally speaking neither the executive nor the lay member of the community are scientifically minded; they may be gulled on the one hand into regarding the application of science as a panacea for all problems, and on the other into a non-committal or even a hostile attitude. We consider that the politician, the scientist, the economist, the industrial executive and the representative of organised labour should work together as equals, each supplying his professional knowledge and experience to the common pool. The work of most of these categories is generally understood by the community; only an appreciation of science is lacking.

Owing to increases in our knowledge that have accumulated during the last fifty years, a great number of problems to-day can be tackled scientifically. Those who have had no scientific training may not be able to recognise a scientific problem when it is presented to them, nor do they realise when a question is one that should be attacked by scientific method. We hold, therefore, that scientists ought to be consulted much more frequently than they are at present, and we suggest, further, that, when the scientific aspect is of overriding importance a scientist is likely to make a better administrator than someone trained in another discipline.

W. A. WOOSTER,

Hon. General Secretary, on behalf of the Executive Committee of the Association of Scientific Workers.

"Radionics" or "Electronics"?

THE following letter appears in the American journal *Science* for 18th June, 1943, and we reproduce it in full, as we think the matter is of interest to our readers. Whatever the relative merits of the words "radionics" and "electronics" we cannot subscribe to the writer's suggestion that since British words were not adopted in other spheres America should continue a policy of independence. Surely mutual agreement on technical terms and words would be a sound policy?

—EDITOR.

"Right now the public is being confused in the Press and on the radio daily by two terms which mean exactly the same thing—'electronics' and 'radionics.' Electronics is of British origin and radionics has been used in our own country for some time, although I don't know who originated it.

"Both these terms deal with the application of vacuum tubes in electrical circuits not only for broadcasting and radio communications, but to radio receivers, television, radar, photo-electric units, rectifiers, phonographs, hearing aids and other devices comprising this entire field.

"Let's take a quick look at these two words.

"'Radionics' springs from the Latin 'to radiate,' and the Greek 'ion' (to wander or travel), and thus we get the term 'wandering or travelling radiations,' which is much to the point and extremely descriptive.

"The first syllable of 'electric,' 'electricity,' 'electronics,' springs from the Greek root meaning 'amber,' which they discovered had certain properties when rubbed. Therefore I take it electronics is wandering amber. Is that descriptive?

"The term 'electron,' as thought of to-day, is of British origin, having been first used by C. J. Stoney in 1891. Since we did not adopt the British words petrol, underground, bobby, pub, valve and wireless, but instead are using the Americanisms—gasoline, subway, cop, saloon, tube and radio, why should we adopt the word 'electronics'?

"Incidentally, in the early days of radio, the same confusion existed in the American public mind between radio and wireless as now exists between radionics and electronics.

"Even the physicists have said 'Radionics is more descriptive.' Dr. Arthur F. Van Dyck, president of the Institute of Radio Engineers, said at the Chicago annual dinner of the Institute on December 18th last: 'Recently I heard a term for these new radio fields which seems apt. It is radionics. That seems to be a good term if we want to find one which will win friends and influence people.'

"My point is, we have a good American word in radionics, highly descriptive, looked upon with favour by engineers and physicists, and easily understood by the general public. A word that, in my opinion, is fit to describe the miracles now being wrought behind the secret panels of radionic laboratories—wrought for the winning of the war. A word that includes the entire field of radar, electronics and radio in one covering term.

"Over the long-distance telephone in the past few days I have talked with most of the leaders of the industry, and of the two terms all of them seem to feel the American term radionics is more descriptive and will be less confusing to the public.

"For the sake of our entire industry I would be deeply interested in the reaction of the Press. May I have your opinion?

E. F. McDONALD, Jr."

Wireless Patents

A Summary of Recently Accepted Specifications

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

552 854.—Stereophonic system of sound reproduction in which substantially the whole of the transmission is limited to a single channel.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 31st October, 1941.

553 030.—Construction of microphone of the differential type wherein a number of apertures are provided to form granule chambers.

G. R. Fountain, Ltd.; G. R. Fountain; A. E. C. Snell; H. J. Houlgate; E. P. Gilbert; and W. J. Haines. Application date 31st October, 1941.

AERIALS AND AERIAL SYSTEMS

552 911.—Short-wave aerial system comprising "folded" dipoles arranged to present a substantially constant impedance over a given range of frequencies.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 31st October, 1941.

552 949.—Method of winding a frame aerial and of mounting it inside a streamlined casing, particularly for use on aircraft.

Standard Telephones and Cables (communicated by International Standard Electric Corporation). Application date 27th February, 1942.

553 633.—Impedance-matching circuit for coupling the feed-line to an aerial system operating over a wide frequency band.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 26th November, 1941.

DIRECTIONAL WIRELESS

553 424.—Single-lobe navigational-beam system wherein the radiating dipole is located below the surface of the ground, and the beam is brought to a focus at ground level.

H. M. Dowsett. Application date 7th April, 1942.

553 529.—Cathode-ray installation for generating polyphase currents at ultra-high frequencies, particularly for the radiation of a direction-indicating beam.

The British Thomson-Houston Co. Convention date (U.S.A.), 31st December, 1938.

553 618.—Means for adjusting the phasing of a crossed-frame directional aerial system.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 16th February, 1942.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

552 822.—Circuit arrangement for developing a constant output voltage from an input which includes undesirable fluctuations.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 23rd December, 1941.

553 028.—Receiver designed to be driven either from A.C. or D.C. mains without the use of an interposed transformer.

Philco Radio and Television Corporation. (Assignees of E. C. Freeland). Convention date (U.S.A.) 16th November, 1940.

553 119.—Ultra high-frequency oscillator, arranged to be converted at will from a simple amplifier to a push-pull stage, and vice-versa.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 6th March, 1942.

553 195.—Arrangement of two independently-biased diodes to serve as an amplitude-limiting input to a band-pass filter.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 6th February, 1942.

553 284.—Preventing undesirable damping of the input circuit of an ultra-high-frequency amplifier which is subject to a variable control bias.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 11th February, 1942.

553 393.—Receiving arrangement for multiplex signals in which separation is effected on a time basis so as to avoid the necessity for using sharply-defined filter circuits.

Standard Telephones and Cables (communicated by International Standard Electric Corporation). Application date 27th February, 1942.

553 401.—Means for minimising the cathode-to-heater capacitance in amplifiers where negative feed-back is applied through the cathode.

Standard Telephones and Cables (assignees of A. L. Stillwell). Convention date (U.S.A.) 1st November, 1940.

553 668.—Means for synchronising the tuning of the transmitter and receiver in a radio system for remote control.

Aga-Baltic Radio Akt. Convention date (Sweden) 6th September, 1939.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

553 255.—Cathode-ray system of colour television in which each successive frame is flood lit with additional light of the appropriate colour.

Marconi's W.T. Co. (assignees of E. I. Anderson). Convention date (U.S.A.) 11th February, 1941.

553 302.—Synchronising system for television wherein sequentially-recurring groups of pulses include a fundamental frequency followed by an harmonic of that frequency.

The British Thomson-Houston Co. Convention date (U.S.A.) 10th September, 1940.

553 370.—Saw-tooth oscillation generator comprising a cathode-ray tube in which the electron beam is deflected relatively to an output electrode having variable secondary-emission properties.

International Television Corporation ; P. Nagy ; and M. J. Goddard. Application date 13th June, 1941.

553 381.—Television system in which the signals are "clipped" and passed through a biased diode in order to apply what is known as gamma correction.

Marconi's W.T. Co. (assignees of K. R. Wendt). Convention date (U.S.A.) 27th November, 1940.

553 403.—Saw-tooth oscillation generator wherein the electron beam of a cathode-ray tube is deflected across an output electrode having a secondary-emission coefficient greater than unity.

International Television Corporation ; P. Nagy ; and M. J. Goddard. Application date 13th June, 1941.

553 530.—Electrode system for automatically off-setting the effect of disturbing voltages on the television signals applied to the control electrodes of a cathode-ray tube.

International Television Corporation ; P. Nagy ; and M. J. Goddard. Application date 7th July, 1941.

553 532.—Construction and assembly of the electrode system of a discharge tube wherein signals are generated by traversing a beam across a target electrode to produce secondary emission.

International Television Corporation ; P. Nagy ; and M. J. Goddard. Application date 23rd July, 1941.

553 534.—Preparation and composition of a luminescent screen having predetermined spectral properties, particularly for cathode-ray television receivers.

Marconi's W.T. Co. (assignees of H. W. Leverenz). Convention date (U.S.A.) 25th September, 1940.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television)

552 946.—Phase-modulating system wherein a frequency-modulated wave is heterodyned with a wave of constant frequency, and the output is heterodyned with the original frequency-modulated wave.

Marconi's W. T. Co. (assignees of M. G. Crosby). Convention date (U.S.A.) 12th February, 1941.

552 959.—Valve circuit for generating and smoothing the control voltage used for keying a high-powered radio transmitter.

Standard Telephones and Cables (communicated by International Standard Electric Corporation). Application date 27th March, 1942.

553 266.—Electron-beam device of the velocity-modulated type arranged for the automatic stabilisation of a source of ultra-high frequencies.

The British Thomson-Houston Co. Convention date (U.S.A.) 31st December, 1938.

553 428.—Suppressed-carrier modulating system in which the carrier wave is directly shunted without the use of a bridge or similar differential device.

Standard Telephones and Cables (assignees of W. H. Boghosian ; F. A. Hinshaw ; and H. G. Och). Convention date (U.S.A.) 3rd May, 1941.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

553 131.—Means for preventing intermodulation in a cathode-ray tube of the double-beam type.

A. C. Cossor ; E. E. Shelton ; and H. Moss. Application date 23rd July, 1940.

553 188.—Construction and mounting of the close-spaced electrodes in a valve having a high order of transconductance.

Hazeltine Corporation (assignees of R. C. Hergenrother). Convention date (U.S.A.) 5th March, 1941.

553 191.—Arrangement and construction designed to simplify the manufacture of indirectly-heated cathodes for thermionic valves.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 26th January, 1942.

553 279.—Supports for the electrodes of an electron-discharge tube comprising an apertured plate provided with bushes of resilient material.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 11th November, 1941.

553 335.—Electrode assembly for a valve for the generation of ultra-high frequencies, wherein a cylindrical cathode is arranged to be non-emitting over a selected area.

Standard Telephones and Cables and C. E. Brigham. Application date 31st December, 1940.

SUBSIDIARY APPARATUS AND MATERIALS

552 072.—System for measuring distance by the transmission of radio pulses with time-delay circuits for measuring the echo intervals.

Standard Telephones and Cables (communicated by International Standard Electric Corporation). Application date 16th December, 1941.

552 869.—Electric signalling system for selective remote control.

Standard Telephones and Cables (communicated by International Standard Electric Corporation). Application date, 14th May, 1942.

552 968.—Method of preparing and coating magnetic cores, particularly those used for high-frequency working and permeability tuning.

Standard Telephones and Cables (assignees of E. G. Walters). Convention date (U.S.A.) 8th March, 1941.

553 050.—Cutting and mounting of a piezo-electric crystal for oscillation in the length mode with a low temperature coefficient of frequency.

Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.) 14th December, 1940.

553 091.—" Stacked " arrangement of piezo-electric crystals for driving a valve oscillator at a selected frequency or at an harmonic of that frequency.

Standard Telephones and Cables (assignees of L. F. Koerner). Convention date (U.S.A.) 2nd April, 1941.

553 121.—Method of cutting a piezo-electric crystal to oscillate at a high frequency and to have a low impedance with a minimum of parasitic resonances.

Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.) 19th October, 1940.

553 220.—Multi-channel system of carrier-wave communication.

Standard Telephones and Cables (communicated by International Standard Electric Corporation). Application date 27th March, 1942.

553 280.—Construction of a valve socket or holder comprising superposed apertured plates and springy contact members.

Cinch Manufacturing Co. (assignees of S. M. del Camp). Convention date (U.S.A.) 26th November, 1940.

553 290.—Gain control arrangements for a multi-channel signalling system.

Standard Telephones and Cables (assignees of H. S. Black). Convention date (U.S.A.) 14th June, 1941.

553 402.—Multiplex signalling system in which each message is transmitted on current impulses of a particular and distinctive phase.

Standard Telephones and Cables (assignees of W. H. T. Holden). Convention date (U.S.A.) 17th October, 1940.

553 457.—Cutting and mounting of a piezo-electric assembly having a plurality of operating frequencies.

Standard Telephones and Cables (assignees of H. J. McSkimin and R. A. Sykes). Convention date (U.S.A.) 12th December, 1940.

553 461.—Protective device which normally operates as an insulator, but which serves automatically as a leak or discharge for high-voltage surges.

Igranic Electric Co. and C. E. Randall. Application date 12th May, 1942.

553 466.—Means for offsetting distortion due to the cylindrical-lens field set up between the deflecting plates of a cathode-ray tube.

Philips Lamps (communicated vt N. V. Philips' Gloeilampenfabrieken). Application date 15th May, 1941.

553 569.—Halogen-Methane compound for improving the dielectric strength of a gaseous insulating material.

Standard Telephones and Cables (assignees of H. Skilling). Convention date (U.S.A.) 27th November, 1940.

553 596.—Inductance winding in which secondary resonances are minimised, together with the resulting impedance effects, particularly when the device is used with a valve amplifier.

Standard Telephones and Cables (assignees of A. G. Ganz. Convention date (U.S.A.) 14th November, 1940.

"Bicolon" Covered Wire

PARTICULARS are given in List NSW2 issued by British Insulated Cables, Ltd., Prescot, Lancs, of a new range of instrument wires insulated with a film of organic material based on Nylon. It is claimed that the improvement in toughness, flexibility and resistance to abrasion over ordinary enamelled coverings enable the new wire to be used in cases which generally require a combination of enamel and cotton or silk covering.

Salvaging Paper

WE are constantly being reminded by the Waste Paper Recovery Association of the need for salvaging every scrap of paper and minimising, as far as is practicable, the use of this essential product. Latest figures, however, show that the difference between the quantity of paper salvaged and that required for the legitimate needs of the country runs into thousands of tons a week.

It is suggested that one of the best ways of making up the deficit is for manufacturers, etc., to release some of their stocks of new paper and cardboard which, although now unusuable owing to the cessation of the manufacture of certain products, they are retaining on the grounds that " it may come in useful one day."

Institute of Physics

SIR FRANK SMITH was elected president of The Institute of Physics at the annual general meeting held recently. The following officers were also elected to fill the vacancies that will occur on October 1st: vice-presidents, E. R. Davies, Dr. W. Makower and T. Smith; honorary treasurer, Major C. E. S. Phillips; honorary secretary, Prof. J. A. Crowther; ordinary members of the Board, Prof. J. D. Cockcroft, D. C. Gall, Dr. H. Lowery, D. A. Oliver, A. J. Philpot and R. S. Whipple.

GOODS FOR EXPORT

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is not necessarily an indication of the importance attached to the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

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PROPAGATION OF WAVES

2294. THE RADIATION OF A CAVITY WAVE FROM A CIRCULAR-SECTIONED HOLLOW TUBE DEBOUCHING INTO A PLANE [Conducting] SCREEN: PART I.—H. Buchholz. (*Arch. f. Elektrot.*, 31st Jan. 1943, Vol. 37, No. 1, pp. 22–32.)

Author's summary :—" The Huyghens principle is first discussed with regard to its mathematical and physical content, and it is then shown how, with its help, the external radiation field of an open and unscreened tubular conductor can be determined on general lines.

" The calculation of this radiation field is then carried out in detail by this method, for a hollow conductor which is traversed by a transverse magnetic wave (' TM ' wave) and which debouches with its end cross-section in the plane of an infinitely extended, perfectly conducting screen, which can be realised approximately by the surface of the earth. The electric field component of the external radiation field fulfils in the plane of the screen all the boundary conditions involved. This is not so for the magnetic component ". Two further parts will come later, the main object being to compare the approximate solution given by the Huyghens method with the strict solution which is possible for this particular case. The paper follows on the writer's previous work (dealt with in 2402 of 1941) from which the present eqn. 3.2 is taken for the vector component of the cavity-line dipole field.

2295. " ELECTROMAGNETIC WAVES " [Book Review].—S. A. Schelkunoff. (*Proc. I.R.E.*, May 1943, Vol. 31, No. 5, p. 245.) " A masterful treatment of an elusive subject ", including " a most thorough analysis of wave transmission, with emphasis on wave guides, cavity resonators and antennas . . ."

2296. ON THE REFLECTION OF AN ELECTROMAGNETIC IMPULSE FROM THE HEAVISIDE LAYER [and the Resulting Deformation].—V. L. Ginsburg. (*Journ. of Phys.* [of USSR], No. 3/4, Vol. 6, 1942, pp. 167–174: in English.)

" In the course of investigation of the Heaviside layer, and in a number of other cases of observation of radio signals reflected from this layer, the questions of the time lag, the time of establishing the amplitude, the shape of the signal, etc., arise. Usually one confines himself to the statement that the time spent by the signal in travelling up and down is $\Delta t_{gr} = \int_L dx/u\,(x,\ \omega_0)$, u being the group velocity, ω_0 the carrier frequency of the signal, and L the way of the signal. However, as far as the amplitude of the reflected signal is not established momentarily, even if the initial signal is sharply cut off, the conception of the time lag calls for some refinement and determination. The time of establishment, time lag, and the kind of deformation of the signal depend on the properties of the reflecting layer. In order to determine these properties, their connection with the shape of the reflected signal must in its turn be found."

Assuming the initial signal to be of the form of a cut-off sine wave (for a short discussion of the case where the cut-off is not abrupt *see* final paragraph, on p. 174), the writer first examines the reflection from a parabolic layer, $N(x) = \beta x^2$. For here the calculations can be more strict than in other cases, the electric field $E(t)$ of the reflected signal (eqn. 4) being expressible by means of the

Fresnel integrals C and S, so that eqn. 14 is obtained for E, and this, on the assumptions of the investigation, simplifies to eqn. 16. Assuming the duration of the initial signal, T, to be much greater than $\sqrt{2\pi a}$ (for a see eqn. 12 for the group time lag with a parabolic layer: $\Delta t_{gr} = \pi\omega/c\sqrt{\epsilon\beta} = 2a\omega$), then, for the range of variation of θ for which $\theta \ll T$ (eqn. 17: θ is the time interval counted from the moment of arrival, at the point of observation, of a signal travelling without deformation with the group velocity corresponding to the frequency ω_0), the expression for $|E|$, the amplitude of the signal after reflection, is obtained in eqn. 18. This involves the Fresnel integrals and $u\ (= \theta/\sqrt{2\pi a})$. "The dependence of the expression (18) on u is well known. In fact it determines the intensity of a wave in the case of Fresnel diffraction on the screen edge (Fig. 3). For $\theta = 0$, $|E| = \frac{1}{2}$. Therefore, after the time interval Δt_{gr} the intensity of the reflected signal attains one fourth of the intensity of the initial signal. The 'time of establishing the amplitude', τ, has the order of magnitude of $\sqrt{2\pi a} = \sqrt{\pi\phi''(\omega_0)}$ [$\phi''(\omega) = (d^2\phi/d\omega^2)_{\omega=\omega_0}$, $\phi(\omega)$ being the phase lag of the reflected wave with respect to the incident wave]. If, as has been supposed when going over to eqn. 18, $T \gg \tau$, only the ends of the signal are deformed, *i.e.* only the region where the condition of eqn. 17 is fulfilled is of interest. The 'time of establishing' may be conventionally put equal to

$$\tau = \sqrt{2\pi a} = \sqrt{\pi^2/c\sqrt{\epsilon\beta}} \approx 7.6 \times 10^{-8}/\beta^{\frac{1}{2}} \text{ sec.}$$

As is clear from Fig. 3, the time interval during which the amplitude of the signal differs, for $\theta > 0$, from the established amplitude by more than 5% . . . exceeds τ approximately 8 times . . ."

For a linear layer ($N(x) = \alpha x$) eqn. 29 is obtained, which is very similar to eqn. 16 for the parabolic layer. For both layers, when $\theta = 0$, $|E| = \frac{1}{2}\ (|E_0|) = \frac{1}{2}$ and $\tau = \sqrt{\pi\phi''(\omega_0)}$. For layers other than linear or parabolic the investigation is complicated by the absence of the knowledge of the analytical expression of dependence of $\phi(\omega)$ on ω, but eqn. 31 is derived of which "one may hardly doubt that it holds for any monotonically increasing function $N(x)$ satisfying some conditions, which are clear from the above considerations". The validity of the approximations used, and the magnitudes of β and α for the E and F layers, are estimated in the final section 4, where it is also mentioned that "the measurement of τ may in principle be made use of for obtaining some information concerning the shape of the layer".

2297. Apparent Correlation between Sunspot Activity and Pressure Distributions in Earth's Atmosphere [in Three-Month Periods showing 80 or more Spots, Pressures tend to be Low near Equator and High in Areas well to N and S of It: Reverse in Periods showing 5 or less].—I. I. Schell. (*Sci. News Letter*, 1st May 1943, Vol. 43, No 18, p. 284.) From Blue Hill Observatory.

2298. On the Presence of Phosphorus in the Solar Atmosphere, *and* Evidence of Gold in the Sun.—K. N. Rao: Charlotte E. Moore & A. S. King. (*Sci. & Culture* [Calcutta], April 1943, Vol. 8, No. 10, pp. 423–424: *Sci. News Letter*, 1st May 1943, Vol. 43, No. 18, p. 285.)

2299. Integral Spectrum of the Galaxy [Isolation of Light of Galaxy proper by Subtraction of Components due to Sky Luminosity, Zodiacal Light, & Dispersed Scattered Light of the Total Star Background].—P. P. Dobronravin. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 30th Oct. 1941, Vol. 33, No. 3, pp. 198–201: in English.)

2300. The Elliptic Meteors and the Zodiacal Light.—B. Fessenkoff. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 20th Oct. 1941, Vol. 33, No. 2, pp. 120–121: in French.)

"It is practically certain that the zodiacal light is due to the matter in the state of powder which fills the planetary system. Robertson has shown, however, that this matter must fall towards the Sun generally in an interval of time which is short in comparison with the age of the solar system. Consequently the particles of the zodiacal light must be replaced continually. The distribution of the density and the general aspect of the zodiacal light are in accord with the hypothesis of emission from the planetoids, probably as a result of their encounter with meteorites. It may be asked whether the particles of the zodiacal light, on encountering the Earth, become visible as shooting stars." The writer's calculations indicate that the *velocities* of the particles at a distance r from the Earth are practically independent of the direction, but that their *number* varies very greatly with α. These properties are incompatible with the spatial distribution of meteors, judged by their diurnal periodicity: the answer to the question is therefore in the negative.

2301. Temperature in Shock Waves and the Possible Connection with the Luminosity of Meteors.—H. Muraour. (*Journ. Roy. Aeron. Soc.*, May 1943, Vol. 47, No. 389, pp. 209–210.) R.T.P.3 Abstract.

2302. New Cosmic-Ray Theory [Protons splitting into Ten Mesotrons: satisfactorily accounts for Latitude & Altitude Effects].—W. F. G. Swann. (*Science*, 30th April 1943, Vol. 97, No. 2522, Supp. p. 10.)

2303. Further Tests of the Atom-Annihilation Hypothesis as to the Origin of the Cosmic Rays.—R. A. Millikan, H. V. Neher, & W. H. Pickering. (*Phys. Review*, 1st/15th April 1943, Vol. 63, No. 7/8, pp. 234–245.)

2304. Characteristic Functions of Transmission Lines [Illustrated Tabulations giving Formulae of Characteristic Impedance].—S. Frankel. (*Communications*, March 1943, Vol. 23, No. 3, pp. 32 and 34, 35.)

"While some of the configurations listed may not appear to have any direct practical value, they are nevertheless useful as intermediate steps in computing the properties of practical configurations": *see* for example Frankel, 329 of February. They include concentric and eccentric lines (the former also with a square outer conductor), a five-wire line, and such things as a balanced 2-wire line near a grounded corner.

2305. TRAVELLING WAVES IN HIGH-VOLTAGE ALTERNATOR WINDINGS [with Extensive Investigation of the Case of the Concentric-Conductor Winding].—E. Friedländer. (*Journ. I.E.E.*, Part II, Oct. 1942, Vol. 89, No. 11, pp. 492–506: Discussion pp. 506–508.)

2306. ON RAYLEIGH WAVES ON THE CONFINES OF TWO SOLID ELASTIC MEDIA [and the Derivation of the Necessary & Sufficient Conditions for Their Occurrence].—V. G. Gogoladze. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 10th Oct. 1941, Vol. 33, No. 1, pp. 15–17: in English.) The method is also applicable to contact between gliding solids and between a solid and a fluid.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2307. TRACING THUNDERSTORMS: A USE FOR ATMOSPHERICS.—J. S. Forrest. (*Wireless World*, July 1943, Vol. 49, No. 7, pp. 192–194.)

2308. DISCUSSION ON "THE ELECTRIC SPARK IN AIR."—J. M. Meek. (*Journ. I.E.E.*, Part I, May 1943, Vol. 90, No. 29, pp. 197–202.) A summary of this paper and discussion was referred to in 1301 of 1942. The original paper is in *Journ. I.E.E.*, Part I, Vol. 89, p. 335 onwards.

2309. DISCUSSION ON "THE LIGHTNING DISCHARGE."—C. E. R. Bruce & R. H. Golde. (*Journ. I.E.E.*, Part II, Dec. 1942, Vol. 89, No. 12, pp. 646–651.) Continued from 966 of 1942: among others, G. D. McCann discusses some Westinghouse results and T. V. Lironi brings up the question whether proneness to lightning disturbances depends on geological formation.

2310. LIGHTNING SHIELD REPLACES MORE CUMBERSOME, COSTLY METHODS [Steel-Wire "Umbrella"].—G. D. McCann. (*Scient. American*, April 1943, Vol. 168, No. 4, p. 174.)

2311. DISCUSSION ON "THE MEASUREMENT OF LIGHTNING VOLTAGES AND CURRENTS IN SOUTH AFRICA AND NIGERIA, 1935 to 1937" [continued from 970 of 1942].—F. R. Perry. (*Journ. I.E.E.*, Part II, Dec. 1942, Vol. 89, No. 12, pp. 653–654.) C. M. Foust describes an insulator-string voltage divider which gives a constant ratio under a wide variety of weather conditions.

2312. THE MEASUREMENT OF LIGHTNING VOLTAGES AND CURRENTS IN NIGERIA: PART 2—1938 TO 1939.—F. R. Perry, G. H. Webster, & P. W. Baguley. (*Journ. I.E.E.*, Part II, June 1942, Vol. 89, No. 9, pp. 185–203: Discussion pp. 203–209.) A summary was dealt with in 1300 of 1942.

2313. SURGE FLASH-OVER MEASUREMENTS ON ROD GAPS [Report on Large-Scale Swiss Investigations: the Unexpectedly Wide Dispersion of Results, and Its Implications].—W. Wanger. (*Bull. de l'Assoc. Suisse des Élec.*, 21st April 1943, Vol. 34, No. 8, pp. 193–201.)

2314. THE BEHAVIOUR OF SURGE ARRESTERS TO CLOSE LIGHTNING STROKES [Theoretical Investigation, with Curves].—K. Berger. (*Bull. de l'Assoc. Suisse des Élec.*, 20th May 1942, Vol. 33, No. 10, pp. 272–284: in German.)

The calculation of the effect of a close direct stroke, unlike that for a distant stroke, is based on a quasi-stationary treatment: the results can be expressed very clearly, and provide all the characteristic values of the behaviour of the arrester as functions of all the variables—duration and amplitude of the lightning current, resistance of the ground at the point of impact, distance between the stroke and the arrester, and residual voltage of the arrester.

2315. RECOMMENDATIONS FOR THE PROTECTION OF ELECTRICAL INSTALLATIONS AGAINST OVER-VOLTAGES OF ATMOSPHERIC ORIGIN.—A. S. E. (*Bull. de l'Assoc. Suisse des Élec.*, 20th May 1942, Vol. 33, No. 10, pp. 291–303: in French.)

2316. LIGHTNING PROTECTION OF BURIED CABLE [including the Surge Tests on the Stevens-Point/Minneapolis Cable].—E. D. Sunde. (*Bell Lab. Record*, May 1943, Vol. 21, No. 9, pp. 294–299.)

2317. DISCUSSION ON "THE SURGE CHARACTERISTICS OF TOWER AND TOWER-FOOTING IMPEDANCES" [384 of 1942].—R. Davis & J. E. M. Johnston. (*Journ. I.E.E.*, Part II, April 1942, Vol. 89, No. 8, p. 168.)

PROPERTIES OF CIRCUITS

2318. DEVICE FOR INFLUENCING CENTIMETRIC WAVES [in Amplitude & Phase].—M. Dieckmann & O. Stützer. (*Hochf:tech. u. Elek: akus.*, Feb. 1943, Vol. 61, No. 2, p. 61.)

D.R.P.723 757. Two metal plates, parallel both to the direction of propagation P (Fig. 2) and to the field vector E, are arranged at a variable distance from each other of about a half-wavelength, and introduced, for instance, in the run of a tubular transmission line.

2319. THE GENERATION AND AMPLIFICATION OF DECIMETRIC AND CENTIMETRIC WAVES.—Hollmann. (*See* 2353.)

2320. High-Frequency Diode-Rectifier Circuit [with Advantages of Small Time Constant & Half-Wave Rectification].—H. Gollub. (*Hochf:tech. u. Elek:akus.*, Feb. 1943, Vol. 61, No. 2, p. 62.)

A Telefunken patent, D.R.P. 723 422. The ends of the inductance of the oscillatory circuit K (Fig. 9) are connected through a series connection of the diode D and a non-rectifying capacity C of equal capacitance. The rectified voltage is taken off a resistance R connected between the mid-point of the oscillatory-circuit inductance and the junction of the diode and condenser.

2321. Fluctuation Phenomena in Amplifier Circuits [Survey of Recent Knowledge: including Valves employing Secondary Emission].—C. J. Bakker. (*Philips Tech. Rundschau*, No. 5, Vol. 6, 1941, p. 129 onwards.) For a long summary in German see *Bull. de l'Assoc. Suisse des Élec.*, 28th Jan. 1942, Vol. 33, No. 2, pp. 45–47.

2322. Filtered Thermal Noise: Fluctuation of Energy as a Function of Interval Length.—S. O. Rice. (*Journ. Acous. Soc. Am.*, April 1943, Vol. 14, No. 4, Part 1, pp. 216–227.)

Author's summary:—" Let a source of thermal noise be connected to the input of a band-pass filter. Consider the energy which would be dissipated during the interval t_1 to $t_1 + T$ if the output current were to flow through a resistance of one ohm. When T is held fixed and t_1 regarded as a random variable, the resulting energies have a distribution whose average and standard deviations depend upon T. Here this dependence is studied. The standard deviation of the difference of the energies of two contiguous intervals, each of length T, is also obtained."

2323. The Transmission Characteristics of Asymmetric-Sideband Communication Networks: Part 2.—E. Colin Cherry. (*Journ. I.E.E.*, Part III, June 1943, Vol. 90, No. 10, pp. 75–88.)

In Part 1 (3636 of 1942) it was shown that the distortion of the modulated wave envelope could be assessed by the calculation of two sets of " equivalent modulation frequency characteristics," thereby reducing the problem to one of modulation frequency only: various types of envelope were considered separately, in connection with television, and the distortions investigated, each type offering different points of interest. " In the present work we are not concerned with the application of asymmetric-sideband channels to any particular form of signal (*e.g.* television), but purely with the 'equivalent modulation frequency characteristics' of such channels, a perfectly general type of modulating wave being assumed. These characteristics, which were evaluated in Part 1, are considered here in greater detail, with some examples": these are both idealised (such as have been chosen by various writers for investigation) and practical (such as the tuned-circuit amplifier). " The theorem is again extended to include the case of a carrier wave modulated by an envelope wave which rises or decays at a rate greater than that of the carrier itself (that is, a wave spectrum containing 'negative' sidebands)."

2324. Video-Amplifier Low-Frequency Correction: an Analysis of Plate-Filter Compensation.—Lynch. (*See* 2440.)

2325. Supplement to Data Sheets 39 to 44: the Cathode Follower: Part III—(a) Noise Performance: (b) Amplifier Circuits: Cathode Follower as Driver.—(*Electronic Eng:g*, June 1943, Vol. 16, No. 184, pp. 21–24.) Following on 1023 of April.

2326. Negative Feedback: Some Pitfalls in Applying It to Quality Amplifiers.—J. T. Terry. (*Wireless World*, July 1943, Vol. 49, No. 7, pp. 198–201.)

" Thus you will see that in applying negative feedback to a circuit, it is necessary not only to make sure that the feedback is truly negative [*i.e.* that it includes a component 180° out of phase: " this postulate is not quite as trivial as it may first appear, as the following example will demonstrate . . ."], and does not affect the operating point, but also that it can achieve your requirements in principle" [" Thus, it seems axiomatic that feedback can correct frequency distortion in voltage amplifiers if, and only if, the distortion is not due to series-resonance"]. The elimination of amplitude and frequency distortion in pentode or beam-tetrode output stages is dealt with at the end of the article.

2327. Lévy's 1932/3 Work on Negative Feedback [*see*, for example, 1932 Abstracts, p. 338, and 1934 Abstracts, p. 388].—M. Lévy. (In Discussion of Reyner's paper dealt with in 2578, below.)

2328. The Correction of Transformer Faults by Complex Negative Feedback.—H. Oltze. (*Alta • Frequenza*, Nov./Dec. 1942, Vol. 11, No. 11/12, pp. 557–560.) Long illustrated Italian summary of the German paper dealt with in 999 of 1942.

2329. " The Use of Secondary Electron Emission for Trigger or Relay Action" [Notice of Pamphlet].—A. M. Skellett. (*Scient. American*, April 1943, Vol. 168, No. 4, p. 189.) A 12-page illustrated booklet on the work dealt with in 1567 of May: *see* also *Bell Lab. Record*, April 1943, Vol. 21, No. 8, pp. 233–236.

2330. A Direct-Current Amplifier and Its Application to Industrial Measurements and Control.—Gall. (*See* 2577.)

2331. The Frequency Characteristic of Resistance-Capacitance-Coupled Amplifiers [and the Influence of the Coupling Capacitance and the Limited Bridging-Condensers for the Cathode Resistance & the Screen-Grid Series Resistance: etc.].—

Editorial. (*Telefunken-Röhre*, Aug. 1941, No. 21/22, p. 243 onwards.) With four diagrams.

2332. Resistance – Capacitance Oscillators: the Comparative Frequency-Stabilising Effects of a Parallel Diode and Triode.—M. Lévy. (In Discussion of Reyner's paper dealt with in 2578, below.)

2333. *RC* Generators [Paper from the Rohde & Schwarz Laboratories].—K. Bucher. (*T.F.T.*, Dec. 1942, Vol. 31, No. 12, pp. 307–313.)

Although it would appear from the literature that America first developed this type of oscillator to a practical form, " nevertheless the principle and mode of action of such generators was first pointed out in Germany. Years ago Prof. Barkhausen called attention to the possibility of producing pure sinusoidal oscillations in back-coupled *RC* amplifiers in suitable conditions (" Elektronenröhren ", Vol. 3). There is no doubt that this type of generator will establish itself more and more, for it shows many superiorities over previous oscillation-generators, both in electrical properties and in mechanical construction."

The present paper does not attempt an exhaustive treatment of all the already known and more or less tried-out circuits in this field, but sets itself rather to explain the nature and action of all such arrangements by the analysis of some little-tried and little-known circuits; as a result of this investigation, the design is described of a simple oscillator with a non-linear-distortion factor of 3%, an output voltage of $10\ v_{eff}$ at a 1-kilohm output resistance, a frequency constancy over 5 seconds of 1×10^{-5}, over 5 minutes of $2–4 \times 10^{-5}$, and a frequency range (in five stages) from 30 c/s to 300 kc/s: *cf.* Willoner & Tihelka, 2026 of 1942 [and 1855 of July]; Gauger & Berrang, 2025 of 1942; Delaup, 1872 of 1941; Ginzton & Hollingsworth, 2161 of 1941 [also Tucker, 1854 of July]. It has two valves, an EBF 11 and an EL 11 (Fig. 17); in order that conditions for the *RC* sections may be favourable at the high frequencies, *R* for low frequencies is chosen as high as possible (10 megohms: no increase above this was found advisable). A network of the " second type " is employed (resistances as series elements, condensers as shunt elements: Figs. 8, 9, compared with " first type ", Figs. 6, 7), controlled by an ordinary broadcast-receiver triple rotary range-change switch (there are three condensers), each of the five positions covering a 1 : 10 frequency range. " The separate frequency ranges of the range switch join up together. Unfortunately, as the frequency increases it is impossible so to design the circuit components that the circuit is free from phase errors: from about 15 kc/s stray circuit capacities make themselves increasingly evident. As a result, no overlapping of scales is possible for the five ranges: on the contrary, for the higher frequencies the scale is drawn apart. This effect is examined more closely in section 2 of this paper. The output resistance of 1 kilohm is easily attained by a suitable negative feedback of the EL 11. An output transformer is unfortunately impossible, since it would not give a transmission range of 30 c/s to 300 kc/s."

Such is the simple, long-range instrument described in Part C and shown in its finished form in Fig. 19. Section 6, however, points out that convenient and obvious though the use of ordinary broadcast-receiver a.v.c. valves may be (in the above circuit the EBF 11 is such a valve, having a logarithmic characteristic and an auxiliary diode system which generates the control voltage necessary for the amplitude-limiting process essential for the whole scheme), nevertheless such an arrangement does not fulfil high requirements as to frequency-characteristic and non-linear distortion. For this purpose, amplitude-limitation at a third grid, using the current-distributing principle, is advisable: the EF 14 is very well suited, having also the necessary steep slope. Fig. 14 shows the anode current in such an arrangement as a function of the grid input alternating voltage, the current-distributing-grid voltage serving as parameter for the five curves: the control, though not the ideal as shown in Fig. 10, is much better than that given by a logarithmic characteristic.

Such a circuit, having its amplitude-limitation carried out on the current-distributing principle, is seen in Fig. 16 and discussed on p. 312, l-h column. The *RC* network is here of the " first type " (*see* above), the series elements being fixed condensers and the shunt elements three ganged potentiometers. Measurements show extremely good results, a non-linear-distortion factor of only 2–3‰ and a frequency constancy of 1×10^{-5} over 5 minutes. No frequency range is mentioned for the tests.

2334. The Synchronisation of Oscillators: Part III — Synchronisation to Harmonics and Sub-Harmonics: Other Methods of Synchronisation.—D. G. Tucker. (*Electronic Eng:g*, June 1943, Vol. 16, No. 184, pp. 26–30.)

For previous parts *see* 1853/4 of July. The present part includes sections on a frequency divider not capable of free oscillation (*see* also 1052 of April); synchronisation to sub-harmonics (" it is not generally realised that such a process is a very efficient means of generating harmonics, singly or in a group of three adjacent ones, particularly when the harmonics concerned are of a high order ": this point is developed); and synchronisation methods not using an injected tone (control by motor, electrical control using valve as variable element).

2335. The Synchronisation of Oscilloscope Sweep Circuits: a Lucid Graphical Analysis.—W. R. MacLean. (*Communications*, March 1943, Vol. 23, No. 3, pp. 23–24, 26–30, and 74.)

Gas triodes: linearity: simple synchronisation: multiple synchronisation: " regular sync zones " (and the work of Builder & Roberts, 2926 of 1940, and of Ghiron, 4306 of 1938): over-synchronisation: sweep wave as time base: bibliography.

2336. Calculation of Natural Frequencies common to Coupled Oscillating Circuits, in a Special Case.—M. Parodi & F. Raymond. (*Rev. Gén. de l'Élec.*, July 1941, Vol. 50, No. 1, p. 62 onwards.) For other recent work by Parodi *see* 663 of 1942.

2337. CORRESPONDENCE ON "THE ELECTRO-MECHANICAL ANALOGY IN OSCILLATION THEORY" [1314 of April].—F. Aughtie & H. L. Cox: R. G. Manley. (*Journ. Roy. Aeron. Soc.*, May 1943, Vol. 47, No. 389, pp. 161–162.)

2338. THE DESIGN OF FOUR-TERMINAL NETWORKS OF PURE REACTANCES WITH GIVEN TRANSMISSION FUNCTION.—G. Cocci. (*Alta Frequenza*, Vol. 10, 1941, p. 470 onwards.) Referred to in 2339, below.

2339. FILTERS WITH A MINIMUM NUMBER OF ELEMENTS.—G. Cocci. (*Alta Frequenza*, Nov./Dec. 1942, Vol. 11, No. 11/12, pp. 482–556.)

A great step forward in the field of filter design was the introduction of the methods, due chiefly to Cauer, which enabled a filter to be designed so that its attenuation/frequency characteristic should approximate, as closely as desired, to a predetermined one over the whole frequency range. "To arrive at this result, attractive as it was, it was however necessary to have recourse to systems of calculation neither simple nor brief, and moreover to limit oneself to special networks endowed with a particular property (regularity of the image impedances) which would simplify the labour of design; thus one was severely limited in the choice of possible networks and forced, in addition, to use systems with a number of elements larger than that strictly necessary for fulfilling all the actual requirements of the filter.

"Keeping to the general ideas of the Cauer-type methods (determination of the component elements of filters with transmission function of attenuation/frequency which will approach closely, and over the whole frequency range from 0 to ∞, a predetermined characteristic such as will fulfil high practical requirements), the present work sets out to give, as a practical application of the theory previously developed (2338, above), some contributions to the process of filter-design; a process which consists, in general, of the following stages:—(1) choice of the type of function which will satisfy the general requirements relating to the required filtering properties; (2) actual determination of the transmission function of the selected type, with the characteristic best adapted to the special requirements of the particular problem; (3) determination of the circuit and the values of the elements (inductances and capacitances) which are to form the quadripole of pure reactance having the transmission function decided on.

"As regards the first point, the contribution of the present work will consist chiefly in presenting, after a 'norming' and classification of types of transmission function, some diagrams which result from lengthy and laborious systematic calculations but which are quickly and easily applied by the reader, and which indicate directly the type of transmission function best corresponding to the filtering requirements of any particular case and allow the design to be carried out with the smallest number of elements.

"Regarding the second and third points, whose theory has been fully developed in the paper already cited [*loc. cit.*], the scope of the present work is to demonstrate the concrete applications to the case of filters, essentially through practical and numerical examples." Finally, in Part III (pp. 545–556) the possibility is pointed out of extending the new method to a great variety of cases ever more complex, and of taking into account the effects of the resistance and other imperfections of the network in its practical form as compared with the purely reactive system.

Part I, on the determination of the transmission functions for filters with the minimum number of elements, deals first with those of the low-pass type, but pp. 496–504 give the extension to other types (high-pass, band-pass, and band-stop) by means of frequency or reactance transformations. An appendix deals with the analytical process used for the calculation of the optimum transmission functions. Part II deals with the methods described in the earlier paper for the design of quadripoles having the chosen transmission function. Use is made here of O. Brune's procedure described in his paper dealt with in 1932 Abstracts, p. 280, l-h column. The final Part III has been referred to above: it ends with a summary of conclusions as to the advantages of the method.

2340. CONJUGATE IMPEDANCES AND SEPARATING FILTERS.—H. Piloty. (*T.F.T.*, Oct. 1942, Vol. 31, No. 10, pp. 255–265.)

"A reactance quadripole is termed a series-separating filter when, closed at the output end with an ohmic resistance, it displays at the input end an operating resistance which never becomes infinitely large for any real frequency. It is termed a parallel-separating filter, when the same holds good for the input operating conductance. A combination of two suitably designed series separating filters with their inputs in series yields a separating circuit with constant input resistance; a combination of two parallel-separating filters yields the same result when connected in parallel at their input ends. Two separating filters associated in this sense are known as conjugate separating filters.

"The general theory of such combinations has been developed independently by Cauer (3510 of 1939) and myself (46 of 1940), after Norton had first shown (2900 of 1937) how to calculate separating filters with predetermined, special operating properties. Now the theory of the separating filter stands in very close relationship to the theory of mutually conjugate impedances: by a pair of conjugate impedances I mean the two resistances or conductances of two two-terminal circuits, which have as their sum a constant ohmic resistance or conductance. That this relationship exists has been known since Cauer (3017 of 1941), supported by the results of my paper (959 of 1940), showed that every realisable two-terminal resistance could also be realised in the form of a reactance quadripole with a real terminating resistance.

"It therefore seems to me to be necessary to develop the more simple theory of conjugate impedances independently and to build up from it the theory of conjugate separating filters. This is done in the present paper. I hope in this way to show the full meaning of the first-named theory and to make clear what must be added to it in order to obtain a complete theory of the conjugate separating filter. In these conditions few new results in the field of reactance quadripoles are to be expected. They are to be found for the most part in the earlier papers. . . . Some new results, however, are contained in the present work." As examples the writer quotes the exact establishment and description of the procedure for obtaining the reactive component of a "regular" impedance (*i.e.* one without "poles" at real frequencies, a "pole" being a point where the attenuation becomes logarithmically infinite) from the active component (section I 3); the determination of the current (and voltage) transmission factor of a separating filter as a quotient of two polynomials (section II 2); the criterion for the "all-pass" freedom of a given current-transmission factor (second half of section II 2); and the physical significance of the "generating function" $X(\lambda)$ of a separating filter, defined in section I. Subsection 7 gives some corrections to the writer's earlier paper (46 of 1940) and subsection 8 discusses the terminology (outlined at the beginning and in the course of this abstract) which he employs and which has received some criticism.

2341. Approximate Method for the Calculation of Building-Up Processes in Filter Circuits [Method of the "Line Harp"].—J. Gensel. (*T.F.T.*, Nov. & Dec. 1942, Vol. 31, Nos. 11 & 12, pp. 299–306 & 313–322.)

The mathematical treatment of this problem, of such importance in connection with television signals, telegraphic pulses, etc., presents no difficulty since the introduction of the symbolic calculus, but the numerical working-out is extremely laborious. In a previous paper (2987 of 1940) the writer has calculated the building-up processes with the help of formulae derived from Heaviside's work, and it was shown that a considerable amount of computing and graphical work was necessary even for very simple systems such as the single- and double-circuit band-pass filters of broadcast apparatus. This is chiefly because during the building-up process not only the amplitude but also the phase of the incoming voltage changes with time. Only in particular cases, for instance with d.c. or with frequencies in the middle of the pass band of a band-filter, is the transient process pure in phase. "This simple case is the one which is most frequently investigated in the literature and it will also occupy a considerable space in the present work. Starting from the knowledge of the phase-pure process it is simple, as we shall see, to give for the circuit under investigation an equivalent circuit, based on the so-called 'line harps' [1442 of 1942], which can be calculated easily for any particular transient. The building-up process of this equivalent circuit is then a good approximation for the filter in question.

"The foundations of this approximation method, particularly the definition and behaviour of the 'line harps', have already been described in the paper just referred to. It was shown there that the method yields a very simple construction for the 'building-up function' which serves to characterise the building-up process: this construction consists in the combination of several arcs of circles. The strict formulae on the other hand (as my first-quoted paper showed) require the point-by-point addition of several logarithmic spirals, which in most practical cases is very laborious."

In the November instalment, Section I is summed up as follows:—"If a generator voltage is applied to the input of a circuit, there occurs at the output a voltage whose time-characteristic is represented by a 'building-up function.' This, for $t \rightarrow \infty$, becomes the 'transmission factor' [$\ddot{\mathfrak{U}}(j\omega)$, eqn. 3]; for $\omega \rightarrow 0$ it becomes the 'transition function' [$F_o(t)$, eqn. 7]; so that $\ddot{\mathfrak{U}}(j\omega) = \mathfrak{F}(\infty, j\omega)$, $F_o(t) = \mathfrak{F}(t, 0)$ . . . eqn. 8. The transmission factor describes the stationary state of the circuit, the transition function the behaviour towards a d.c. pulse. From eqn. 8 the relation $F_o(\infty) = \ddot{\mathfrak{U}}(0)$ follows directly: in the next section we shall establish a noteworthy inversion of this relation." This inversion is eqn. 10 in Section II, namely $F_o(0) = \ddot{\mathfrak{U}}(\infty)$: thus the transition function (and also, it is seen later, the building-up function) begins at zero for a low-pass circuit, but with a finite amplitude for a high-pass circuit.

Section II 2 deals with the Fourier integral of the transition function and its development: III 3 introduces the "normed" magnitudes $\Omega = \tau\omega$, $T = t/\tau$, etc., which are used in all the subsequent calculations: by thus introducing the constant τ (time constant $\tau = L/R$), which has kept recurring in the previous equations, the subsequent calculations are simplified.

Section III 4 points out that eqn. 15 for the calculation of $F_o(t)$, the transition function, becomes very laborious when anything but very simple circuits are involved. An approximate procedure is highly desirable, especially since it is intended to use this function for the construction of the building-up function. "In the literature many methods have been described [Macfarlane, Dresden Dissertation, Reference "14": Strecker, 447 & 2460 of 1941] which make possible the calculation of transition functions by idealising assumptions as to the filters in question or by approximate formulae for their transmission factors. In the present paper a way will be described based on an approximate expression for the d.c. impulse. We shall see that by this means we obtain good results, in a simple way, even for complicated circuits." As a first step it is assumed that only low-pass circuits are concerned: an extension to high- and band-pass circuits is dealt with in practical examples in Section IV in the December instalment. Since the transmission factor for a low-pass circuit takes on very small values for large frequencies $\Omega = m\Omega_n$, the infinite Fourier series of eqn. 18 (giving $F_o(T)$ for a rectangular pulse) can be approximately represented by a finite summation. The output voltage given by eqn. 18 has the form shown in Fig. 4a, but for practical use a slightly different Fourier development is preferable, obtained by extending $F_o(T)$ to a periodic function (of the form of Fig. 4b) given in eqn. 19: in some cases a development of the form of eqn. 21 is more convenient. For the frequently encountered circuit of Fig. 3 the transition function as calculated by the approximation given by the first four terms of eqn. 21 is shown in the dotted curve: it is seen to agree extremely well with the full curve derived from the more complex eqn. 15. Thus the approximate method will be satisfactory for many practical cases.

Section III in the December instalment considers the building-up function: (1) its integral representation; (2) its resolution into component systems; (3) the "line harp" and the carrying-out of the equivalent-circuit procedure. Section IV gives practical examples of the application of the method, beginning with a summary of the whole process and then applying it in turn to low-pass, high-pass, and band-pass filters. The course of the procedure may be indicated by the following landmarks:—(i) the determination of the transmission factor $\mathfrak{U}(j\omega)$: (ii) the determination of the transition function $F_0(T)$, by eqn. 15 for the simple circuits or by the approximate method of section II 4 for the more complicated: (iii) when the transition function has been calculated, its curve plotted over the T axis is approximated to by a series of short straight lines, from which the constants T_ν and z_ν can be obtained: these values can be used as the constants of an equivalent circuit built up of n "line harps", each having a transition function of the form seen in Fig. 7 and expressed in eqn. 29: (iv) construction of a table (such as Table 1) showing, for various values 1..7 of the index ν, the constants z_ν and T_ν and the building-up times $T_\nu - T_{\nu-1}$, and also, for the "normed" frequencies Ω of particular interest (in the case taken, $\Omega = 0.5$ and 1.0), the radii and angles, r_ν and α_ν, calculated from these last three quantities by eqns. 32, 34. With the help of this table it is now finally possible to construct the locus curve, for frequency Ω, of the building-up function, according to section III 3. As a check, the numerical value of the transmission factor may be calculated for the frequency Ω: the point obtained must come near the end point of the locus just constructed.

2342. THE INFLUENCE OF PHASE CONSTANT AND LOSSES ON BUILDING-UP PROCESSES.—G. G. Macfarlane. (*Dresden Dissertation*, 1939, mentioned in 2341, above.)

2343. ACCEPTOR CIRCUIT FOR A VERY WIDE HIGH-FREQUENCY BAND.—G. Weber. (*Hochf:tech. u. Elek:akus.*, Feb. 1943, Vol. 61, No. 2, p. 62.)

A Telefunken patent, D.R.P.723 508. "The filter, with which a wide band-width and high amplification can be attained, and which is to a great extent independent of stray circuit and valve capacities, contains between its input terminals a series resonance circuit L_1C_1 (Fig. 10) tuned to a limiting frequency within the pass band, and also, in parallel with the one inductance L_1, another series-resonance circuit L_2C_2 (with inductance and condenser in the same sequence as in L_1C_1) tuned to another limiting frequency also within the pass band, and with its capacitance C_2 considerably smaller than that of the first series-resonance circuit, C_1". The output voltage is taken off across the L_2 side of C_2 and the remote side (connected to the input terminal) of C_1.

2344. DESIGN DATA FOR *m*-DERIVED TYPE FILTERS, PART I.—(*Journ. Applied Phys.*, May 1943, Vol. 14, No. 5, p. xii: notice of article in *Aerovox Research Worker*.)

2345. A NOMOGRAM FOR DESIGNING BAND-PASS FILTERS.—D. D. D'yakov. (*Izvestiya Elektroprom. Slab. Toka*, No. 4/5, 1940, pp. 16–19.)

It is customary in designing two-sectional band-pass filters to use curves of the type $y = \psi(x)_p$, where y is the relative ordinate of the resonance curve (equations 1 and 2 for couplings above and below the optimum value respectively), x the detuning parameter (4) and p the coupling parameter (3). It is shown that curves of the type $p = \phi(x)_y$ are more convenient, and a family of these is plotted in Fig. 1, which can be regarded as a nomogram. Several numerical examples illustrating the use of the nomogram are given.

2346. CLOSED-FORM STEADY-STATE RESPONSE OF NETWORKS, FOR PERIODIC APPLIED VOLTAGES [with Application, for example, to Smoothing Filters].—S. Frankel. (*Communications*, April & May 1943, Vol. 23, Nos. 4 & 5, pp. 30–36 and 74, 76, & pp. 38..43 and 72.)

"Application of a simple but very useful theorem representing an extension of Laplace-transform methods in which the solution for the response of an electrical system is written as a Bromwich integral by virtue of the Mellin inversion theorem [McLachlan's book, "Complex Variable & Operational Calculus with Technical Applications", is referred to here: ref. "1", and *see* 398 of 1940]. To the best of the writer's knowledge, the extension used here was first presented by Professor A. Hazeltine . . ." in a 1939/40 lecture course.

2347. ELEMENTARY THEORY, MEASUREMENT, CALCULATION AND DESIGN OF ELECTRICAL FILTERS.—R. Sueur. (*Rev. Gén. de l'Élec.*, Sept. & Oct. 1941, Vol. 50, Nos. 3 & 4, pp. 163 & 256 onwards.) With 49 diagrams and many tables.

2348. RADIO DATA CHARTS: NO. 9—THE DYNAMIC RESISTANCE OF A PARALLEL TUNED CIRCUIT.—J. McG. Sowerby. (*Wireless World*, July 1943, Vol. 49, No. 7, pp. 194–196.)

2349. ELEMENTARY A.C. MATHEMATICS: PART IV—PHASE RELATIONSHIPS IN INDUCTANCE AND CAPACITY.—G. Grammer. (*QST*, May 1943, Vol. 27, No. 5, pp. 19–23 and 74..78.)

2350. EQUIVALENT CIRCUIT OF THE ELECTROLYTIC CONDENSER.—C. Wachenhusen. (*Alta Frequenza*, Nov./Dec. 1942, Vol. 11, No. 11/12, pp. 560–563.) Long illustrated Italian summary of the German paper dealt with in 3151 of 1941.

2351. Self-Discharge and Time Constant of the High-Voltage Oiled-Paper Condenser.—C. Brinkmann. (*Arch. f. Elektrot.*, 31st Jan. 1943, Vol. 37, No. 1, pp. 49–58.)

Horst has made measurements on various high-tension condensers in the range of voltages up to 20 and 75 kilovolts (2064 of 1938 [following on 3144 of 1937]), but data are still lacking on the modern high-tension paper condenser with oil impregnation, which will be shown to possess considerably larger time constants than those given by Horst for similar condensers. The writer has therefore made an exhaustive series of measurements on a test condenser of this type, at voltages up to 250 kilovolts: the condenser was of the roll type, with special paper and aluminium foil (Fig. 1), and was made up in various capacities. The loss factors measured on a Schering h.t. bridge kept within the limits 0.004 to 0.008. Precautions were taken to keep the corona losses down so that even at the highest voltages they were negligible.

Fig. 3 shows (for three selected voltages) the curves of the time constants of one particular condenser at the beginning of self-discharge, as a function of the duration of the charging process. Fig. 4 shows the time constants during the discharge, as a function of the charging voltage, and Fig. 5 shows the same for a number of different condensers (differing in capacity and also in nominal and testing voltages). It is pointed out that although, theoretically, the time constant should be merely proportional to the specific resistance and dielectric constant of the dielectric, and thus independent of the capacitance, in practice there is always the complication of surface conduction, losses in lead-in bushes, etc. To the extent that these losses increase less than proportionately with the capacitance, there occurs a certain dependence of the time constants on the capacitances, in the sense that a larger capacitance gives a larger time constant. But this dependence is by no means so great as is often thought, and the present measurements show that a larger capacitance certainly need not be bound up with a larger time constant.

The measured time constants (obtained from the relation $T = t/\log_e U_0/U$, by taking the values at two neighbouring points on the discharge curves) range from 2×10^3 to 2×10^5 seconds. In general, they decrease as the voltage is increased. This is partly due to the voltage-dependence of the insulation resistance, but there is also a dependence on the duration of the applied electrical action: the time constant increases as this increases, for a prescribed voltage, and tends to a final limiting value as the duration is increased. In this way a pre-treatment effect occurs, in that a condenser displays a particularly favourable time constant if it has been previously subjected to a higher voltage.

TRANSMISSION

2352. Development of Micro-Wave Generators of the "Transator" and "Turbator" Type [the Latter with Circular Electron-Flow].—F. Lüdi: Tank. (*Bull. de l'Assoc. Suisse des Élec.*, 3rd June 1942, Vol. 33, No. 11, pp. 321–323: in German.) In the Discussion (illustrated) of Tank's survey dealt with in 1555 of May. For Lüdi's work *see* also 1660 & 1693 of June.

2353. The Generation and Amplification of Decimetric and Centimetric Waves: Part I—Amplification and Retroaction.—H. E. Hollmann. (*T.F.T.*, Nov. & Dec. 1942, Vol. 31, Nos. 11 & 12, pp. 281–293 & 322–332: to be contd.)

"The shortest waves which have hitherto been obtained with transit-time valves are in the neighbourhood of 0.5 cm: below that, only spark excitation has been used up to the present": under the term "transit-time" valves the writer includes the B–K retarding-field type and its variations, various kinds of magnetron, the Farnsworth dynamic secondary-electron multiplier, and the velocity-modulated valves.

Section A of the November instalment deals with power amplification and self-excitation by retroaction in the transit-time region:—(1) The excitation of the induction current: eqn. 2b expressing this current J as a current integral. "This current dominates the behaviour of every electronic valve at high frequencies, and is not only the cause of the decrease of slope in space-charge-controlled valves but also the reason why the grid, even with negative bias (when statically no grid current can flow), shows a h.f. current with positive active component and a corresponding consumption of energy, which finally leads to a failure of the power amplification: on the other hand, this induction current plays a predominant rôle in all transit-time valves." (2) The dynamic resistance of a diode: (a) in the saturation region (pictorial treatment by Sloane & James, 4058 of 1936 [and 983 of 1937] and not as cited in "ref. 1"): (b) in the space-charge region (including formula and curve for transit times for cylindrical electrodes). (3) The space-charge-controlled amplifier valve in the transit-time region: (a) the dynamic grid resistance (refs. 3–11, including North, Strutt, Bakker & de Vries, Benham, Rothe, Kleen): (b) the dynamic slope. (4) The limit of power amplification and retroaction (including eqn. 14 for λ_{min}, giving for a type SD1 valve a min. wavelength of 17 cm: with special resonance circuits a similar valve has actually produced a 20 cm wave). Acorn valves, by eqn. 14, give a min. wavelength of 6 cm: "this seems to be about the limit for retroaction oscillations," since smaller electrode spacings are unlikely to be achieved. "The hope that inertia effects in the grid/cathode space could be neutralised by the lag of the induction current in the grid/anode space, and that the two effects working together might lead to regions where self-excitation could again be possible at many times higher frequencies, has up to the present not been fulfilled owing to the diminishing slope, although measurements have shown the existence of damping-reduction regions of higher order (Hollmann, 1933 Abstracts, pp. 563–564)."

Section B deals with the retroactively-coupled generator:—(1) Self-excited circuits: (a) the three-point connection: (b) symmetrical circuits. (2) Quasi-stationary oscillatory circuits: (a) *LC* type: (b) "tank" circuits (pot and sphere cavities) and their equations. (3) Oscillatory systems with distributed inductance and capacitance (coaxial lines, Lecher wires, etc.).

Section C is headed "power amplification and frequency multiplication": it considers the problem of neutralising the retroaction of the anode circuit on that of the grid, quoting the 1937 work of Samuel & Sowers and Haeff's "inductive-output" amplifier. For the generation of decimetric waves by frequency multiplication with space-charge-controlled valves only two references are given: Lindenblad and Straubel, both of 1935. Section D on decimetric-wave valves includes Table I giving data of German and American types. "Decimetric-wave valves with vacuum bulbs consisting wholly or partly of ceramic material (Baier, ref. "31") have not established themselves in practice."

Many sections of this survey include practical approximate formulae. Part II, in the December instalment, deals with "inversion" oscillations based on an "ultradynamic" valve-resistance (*see* for example 1933 Abstracts, pp. 563–564), with retarding-field valves and magnetrons, and in a later instalment with electrostatic and magnetic multipliers and velocity-modulated ("phase-focused") valves. Part III will consider plasma oscillations, and Part IV spark generators. At the beginning of Part II there is a concise explanation of the terms "ultradynamic" and "inversion oscillations," so often encountered in this writer's work. Thus "ultradynamic" represents the valve in the transit-time region as a complex resistance, as opposed to the static behaviour of the un-loaded valve and also to its dynamic functioning, with a complex external resistance, outside the transit-time region. And "the lagging of the 'induction' current behind the h.f. voltage, becoming ever greater with increasing transit time, leads ultimately to a region in which current and voltage are in phase-opposition. This means that the current/voltage characteristic inverts itself, or the ultradynamic valve-resistance becomes negative and allows oscillations to be set up. The important and fundamental characteristic of an ultradynamic resistance is the frequency-dependence of its active and reactive components, so that it works in the desired sense only under definite conditions of transit time. With steadily increasing transit time the inversions proceed; that is to say, alternate regions of positive and negative resistance follow each other in succession. It can be shown that, fundamentally, any electron-discharge-gap is in the position to generate 'inverse oscillations'; that is, oscillations due to ultradynamic inversions of characteristic (Hollmann & Thoma, "The dynamics of transversely and longitudinally controlled electron beams," 2914 [and 4039] of 1937). In practice the problem is to improve, by special measures, the intrinsically not very high useful energy of such 'inversion oscillations'".

After dealing in considerable detail with the inversion region of a diode, as the simplest example, and citing, at the end, the experimental results of Llewellyn & Bowen (3155 of 1939) as confirming the theoretical conclusion that the energy conversion is too small to be of practical use, the writer then considers, as the next step forward, the ultradynamic induction-current resistance of a double layer traversed by electrons: this leads directly to section II A3 on the cathode-ray tube as an ultra-dynamic oscillation-generator. In section II B on the retarding-field valve, a footnote calls attention to Kockel's work (3230 of 1942) which seems to indicate that the "sorting-out" processes at cathode and retarding electrode are unnecessary and even harmful.

2354. USING HIGH CRYSTAL HARMONICS FOR OSCILLATOR CONTROL [for Ultra-High Frequencies].—Fair. (*See* 2451.)

2355. MAGNETRON ARRANGEMENT WITH ANODE SEGMENTS OSCILLATING IN PHASE-OPPOSITION.—K. Fritz. (*Hochf:tech. u. Elek:akus*, Feb. 1943, Vol. 61, No. 2, p. 61.)

A Telefunken patent, D.R.P.723 692. Only one anode segment, "3" in Fig. 1, is connected to the lead-in through the bulb wall: this lead-in is continued in the form of the central conductor of a coaxial line acting as the tuned circuit, and the bulb itself is at least partly enclosed by the outer conductor of this line. The other anode segment is coupled to this outer conductor by a capacity plate acting from inside the bulb, through the wall of the latter.

2356. MODULATING METHOD FOR MAGNETRONS [Unwanted Frequency Modulation balanced out by Varying the Angle between Axis of Electrode System and Magnetic Field, in Rhythm with the Modulation of the Grid or Anode Voltage].—K. Lämmchen & L. Müller. (*Hochf:tech. u. Elek:akus.*, Feb. 1943, Vol. 61, No. 2, p. 61.) D.R.P.723 758.

2357. "FREQUENCY MODULATION" [Book Review].—A. Hund. (*Review Scient. Instr.*, April 1943, Vol. 14, No. 4, pp. 103–104.)

2358. MODULATION SYSTEM FOR SHORT AND ULTRA-SHORT WAVES.—H. Chireix. (*Hochf:tech. u. Elek:akus.*, Feb. 1943, Vol. 61, No. 2, p. 61.)

D.R.P.723 375. The carrier wave produced by a hard-to-modulate generator is taken through a concentric feeder 1 (Fig. 3) to the point of symmetry of two circuits, each tuned to the carrier wave and each consisting of an inductance L and the internal capacitance of an exponential (variable-mu) valve M. The modulating voltage is applied, through a transformer T, in push-pull to the grids of the two valves, the anodes being connected through the feeders 2, 3 to the load circuit.

2359. ON PARASITIC OSCILLATIONS IN SHORT-WAVE RADIO TRANSMITTERS.—P. V. Shabanov. (*Izvestiya Elektroprom. Slab. Toka*, No. 4/5, 1940, pp. 6–11.)

A high-power push-pull amplifier stage (Fig. 1) is considered and the parasitic oscillations which may occur in various parts of the circuit are discussed. The condition of self-excitation in which the whole of the circuit takes part is also included in the discussion. The factors causing the appearance of the above oscillations and determining their frequencies are pointed out, and a number of practical suggestions for improving the performance of the stage are made.

2360. A HIGH-VOLTAGE PLATE-POWER SUPPLY [for 1600 Volts D.C. & Total Load Current 0.768 Ampere] USING MERCURY-VAPOUR TUBES [Three RCA Type 872–A in Three-Phase Interconnected Zig-Zag Circuit].—S. Helt. (*Communications*, April 1943, Vol. 23, No. 4, pp. 22–24, 26, and 72.)

Ripple was set to be not more than 0.089%, for although the present ripple tolerated in commercial equipment was found in some cases to be 0.25 to 1.0%, the designer was looking towards the future, when the licensing authority will demand reduced noise level in the transmitted signal.

2361. *RC* GENERATORS [Paper from the Rohde & Schwarz Laboratories].—Bucher. (*See* 2333.)

RECEPTION

2362. FREQUENCY-CONVERSION FOR DECIMETRIC WAVES WITH THE HELP OF DIODES.—M. J. O. Strutt & A. van der Ziel. (*Funk* [Berlin], 1st/15th Oct. 1942, No. 19/20, pp. 269–272: from *Philips Tech. Rundschau*, Vol. 6, 1941, p. 289 onwards.)

A summary was dealt with in 392 of February. "The design of amplifier valves with extremely small electrode-spacings, combined with high insulation against large accelerating voltages, and with low electrode capacitances and lead inductances, is only possible for wavelengths down to about 50 cm: and even above 50 cm the amplification factor of these special valves is not very good. Certainly below this wavelength some other method of amplification is essential. One of these methods is the conversion of the signal frequency into a lower, easily amplifiable intermediate frequency, with preservation of the modulation. Naturally, the ordinary mixing valves fail in this task: but a mixing action can, as will be shown here, be obtained with the help of special diodes. Such designs have been developed and described by the Philips Company. Fundamentally, any type of rectifier could be used for mixing, but the diode has considerable advantages over other rectifiers" [for Bell's paper on the diode as rectifier and frequency changer *see* 3343 of 1941].

The process (Figs. 2–4) is analysed: summed up, the mixing action is as follows:—The effective slope of a diode, for a small h.f. input voltage, is acted on by an auxiliary voltage of somewhat lower frequency but high amplitude. Thanks to the biasing voltage U_v, which allows only the positive peaks of the auxiliary voltage to be effective, the resulting periodic curve of slope contains numerous harmonics of the auxiliary frequency. It is with these that a multiplicative mixing of the signal frequency occurs. One of the resulting intermediate frequencies is filtered out by the load resistance of the diode, which takes the form of a resonant circuit. This frequency produces an intermediate-frequency voltage at the load resistance. The ratio of this voltage to the signal voltage (V_c, the conversion amplification) may at the best be unity: for this to occur, care must be taken to make the i.f. resonant circuit of high quality (eqns. 17 and 18 for V_c) and to arrange that the base $2b$ of the slope-curve (Fig. 4) should be as brief as possible. Fig. 5 shows how the length of $2b$ influences the conversion amplification, and how, to obtain the best amplification, it must be made the smaller, the higher the order of the harmonic employed. Thus in order to obtain the same result with the third harmonic as is given with the fundamental when b is about $\pi/6$, b must be made about $\pi/20$. This must be taken into account when deciding which harmonic to employ: and the height of the d.c. voltage, which affects the value of b, must be chosen accordingly.

The special valve developed by the Philips Company for the purpose is shown diagrammatically in Fig. 6. It is indirectly heated, and the cathode/anode spacings of the symmetrical double-diode system (provided so that for a symmetrical input a push-pull arrangement may be used) are only 0.15 mm. The connections are silvered to cut down skin-effect losses. A triode system is included for generating the auxiliary oscillations: it oscillates at 37 cm, so that by using the fourth harmonic a signal of 9 cm can be dealt with. The conversion amplification at 40 cm is about 0.4–0.6. The auxiliary voltage must have an amplitude of about 4 v. The input damping is of the order of 5 kilohms: the resistance increases if a lower intermediate frequency is used. A directly heated type is also made, for battery operation; here the cathode/anode spacing can naturally not be made so small because of the bending of the filament, and the shortest wavelength of the triode system is 80 cm.

The final section discusses the two circuits of Figs. 7 and 8, for the single diode gap and the push-pull arrangement respectively; it ends with an examination of the damping of the input circuit by the diode and an estimation of the resistance of the circuit between the points "1" and "2" of Fig. 7. It is seen that to attain a low damping of the input circuit, the load resistance R_z must be made large; and that the internal resistance of the diode, r_d, must also be large, and since the expression for this (eqn. 26) contains b in the denominator, this is another reason for making b small. It is pointed out in conclusion that the calculations are not strictly accurate for waves below 1 m, since transit-time effects and phase displacements, producing an asymmetrical distortion of the slope-curve of Fig. 4, should all be taken into account: however, "this has naturally only a slight influence on the applicability of the method to decimetric waves, as the values for the conversion amplification for $\lambda =$ 40 cm show".

2363. SUPER-REGENERATIVE DETECTORS IN ULTRA-HIGH-FREQUENCY, *and* AN ULTRA-HIGH-FREQUENCY SUPER-REGENERATIVE RECEIVER DESIGNED FOR LABORATORY STUDY.—A. H. Meyerson. (*Communications*, March 1943, Vol. 23, No. 3, pp. 16, 18–20, 22, 71–72, and 79: April, No. 4, pp. 13–15 and 67..69.)

The first of these papers deals with general principles and design considerations: thus Fig. 14 illustrates various methods of s.r. detection at u.h.f: first a circuit similar to that of an electron-coupled oscillator; then a 6A7 arrangement where the anode and grid act as a quench oscillator and the pentode as a resonant oscillator; a similar arrangement, but with a separate triode section in the valve (a 6K8); and so on. This treatment leads on to the second paper, in which the portable receiver, described in detail, was designed so that it could easily be converted from a self-quenched to a dual-oscillator quench detector, to compare the merits of the two methods. "The circuit was designed more as a standard for comparison of various types of s.r. detectors than for practical use. Provisions were made for variation of those constants which directly affect the operation of the detector." The receiver, as built, was for 100 Mc/s, incorporating a r.f. stage to prevent re-radiation.

2364. A Two-Tube Tuned-Radio-Frequency-Regenerative Frequency-Modulation Receiver.—B. C. Barbee. (*QST*, May 1943, Vol. 27, No. 5, pp. 24–26.)

"The one disadvantage in the system is that the frequency-deviation ratio is only approximately one-tenth what it would be if the signal were first converted to 4.3 Mc/s, the usual intermediate frequency. . . . But isn't it easier and cheaper to stick in an audio-amplifier stage with a gain of 10 than to bother with a complicated frequency-converter stage? Indeed it is . . ."

2365. Receiver for Frequency-Modulated Waves.—K. Küpfmüller. (*Hochf:tech. u. Elek:akus.*, Feb. 1943, Vol. 61, No. 2, p. 62.)

A Siemens & Halske patent, D.R.P.723 384. To keep the noise-level down, the conversion of the frequency modulation into amplitude modulation takes place by means of the resonance curve *B* (Fig. 8) whose width is small compared with the frequency deviation *F*: over-control is prevented by displacing the resonance curve, or the voltage to be demodulated, in time with the derived modulation voltage in such a way that the working point *P* on the characteristic curve *B′* moves about the family of resonance curves.

2366. The Ultra-Short-Wave Receiver with Direct Amplification.—Kenigson. (*See* 2435.)

2367. High-Frequency Diode-Rectifier Circuit [with Advantages of Small Time Constant & Half-Wave Rectification].—Gollub. (*See* 2320.)

2368. A Two-Circuit Receiver with Two High-Frequency Stages and Diode Detection.—G. von Glass. (*Funk* [Berlin], 1st/15th Oct. 1942, No. 19/20, pp. 265–269.)

The contest between multi-circuit "straight" receivers and superheterodynes ended in favour of the latter because they allowed all reasonable requirements to be satisfied more easily. In present conditions, however, superheterodynes require too many components, and the larger models of receiver must be designed as "straight" types. The obvious choice is the standard two-circuit receiver, with h.f. input valve, a retroactive audion, and an output stage. But though this arrangement has an excellent sensitivity, a.v.c. is difficult to obtain satisfactorily, and the back-coupling adjustment is hardly up to modern ideas of receiver "comfort". In view of these facts, and of the importance attached to freedom from distortion, the writer recommends the use of two h.f. stages and diode detection, keeping the diode circuit untuned: a tuned diode circuit does increase the over-all amplification, but this is often inconvenient and introduces oscillation troubles, and moreover the tuned circuit is strongly damped by the low resistance of the diode, so that it contributes little to the selectivity. The presence of the additional h.f. valve improves the a.v.c., the control voltage for which is provided by one system of the duo-diode AB2. The correctness of these and the various other considerations mentioned in the paper is confirmed by the good performance of the finished receiver.

Constructional data are provided, and an alternative circuit diagram is given, for use when metal valves of the "steel" series are to be employed.

2369. Characteristics of High-Fidelity Systems.—Ebel. (*See* 2405.)

2370. The Tapped-Coil Aerial Coupling: the Performance of the Circuit analysed [Selectivity: Effect of Aerial Coupling on Tuning: Calculation of *M* & *k*: Measurement of Effective R.F. Resistance of the Whole Coil (by *Q* Measurements): Best Tapping Point].—S. W. Amos. (*Electronic Eng:g*, June 1943, Vol. 16, No. 184, pp. 14–16.)

2371. Circuit Arrangement for the Suppression of an Interfering Frequency.—J. A. Worcester. (*Hochf:tech. u. Elek:akus.*, Feb. 1943, Vol. 61, No. 2, p. 62.)

An A.E.G. patent, D.R.P. 723 286. The tuned secondary circuit 5 has in series with it an untuned secondary coil 6, coupled to the primary circuit 4 and having connected to it, in parallel or series, a resistance 14 "of such a value that a frequency closely adjacent to the resonance frequency of the tuned circuit (say 9 kc/s away) occurs in phase opposition in the two coils 5 and 6, and is thus eliminated." The same thing can occur in the next stage, with the coils 8 and 9 and the resistance 15.

2372. Beat Response: a Frequently Overlooked Cause of Interference [with Details of an Investigation of a Case of Difference-Frequency Interference caused by Two Broadcasting Stations, and the Search for the Non-Linear Element (Poor Aerial or Earth Connection, Oxidised Relay Contacts, Receiver Circuit, etc.) producing It].—G. E. Hamilton. (*QST*, May 1943, Vol. 27, No. 5, pp. 40–41 and 68.)

2373. Another "Static Stopper" [Paragraph on News Items in *The Times*].—G. J. Candrisen: Goodyear Tire & Rubber Company. (*Electrician*, 2nd July 1943, Vol. 131, No. 3396, p. 3.)

2374. Reducing Power-Line Interference [by Treatment of Insulators with a Semi-conducting Glaze: Photograph of Test]. —American Westinghouse Laboratory. (*Wireless World*, July 1943, Vol. 49, No. 7, p. 211.)

2375. THE CHARACTERISTICS AND PERFORMANCE IN SERVICE OF HIGH-VOLTAGE PORCELAIN INSULATORS [including the Question of Radio Interference].—J. S. Forrest. (*Journ. I.E.E.*, Part II, Feb. 1942, Vol. 89, No. 7, pp. 60–80: Discussions pp. 80–92, and June & Dec. 1942, Nos. 9 & 12, pp. 249–254 & 652–653.) A summary and an abridged version were dealt with in 423 of 1942. For a recent article *see* 2128 of August.

2376. WIRING METHODS [and the Question of Interference to Broadcast Reception & Television].—" Supervisor." (*Electrician*, 2nd July 1943, Vol. 131, No. 3396, pp. 9–10.) Prompted by a pronouncement regarding steel tubing and lead covering: and including a reference to Watson-Watt's " four freedoms " for the listener (*see* 2523, below).

2377. ANTI-INTERFERENCE [and the Question of Payment for the Installation of Suppressing Devices: Swiss Agreement]. — (*Wireless World*, July 1943, Vol. 49, No. 7, p. 216.)

2378. BROADCASTING AS A CONSUMER OF ELECTRICAL ENERGY [World Data for 1939, Stations & Receivers].—(*E.T.Z.*, 5th Nov. 1942, Vol. 63, No. 43/44, p. 524: summary only.)

Yearly consumption per receiver is given as 48.5 kwh for Europe, 50 for the other continents, except Oceania, which is given 100 and also the largest consumption per kw in aerial in transmission. Adding the consumption in the industry and trade, the yearly world total comes to 5–6 milliards of kwh, about 80% being due to the receivers.

2379. SIGNAL-STRENGTH CODE [Note on Code for Oversea Listeners reporting on Short-Wave Transmissions, recommended by B.B.C. Engineers]. — (*Wireless World*, July 1943, Vol. 49, No. 7, p. 215.)

AERIALS AND AERIAL SYSTEMS

2380. THE RADIATION OF A CAVITY WAVE FROM A CIRCULAR-SECTIONED HOLLOW TUBE DEBOUCHING INTO A PLANE CONDUCTING SCREEN: PART I.—Buchholz. (*See* 2294.)

2381. THE TAPPED-COIL AERIAL COUPLING: THE PERFORMANCE OF THE CIRCUIT ANALYSED. —Amos. (*See* 2370.)

2382. ON THE CALCULATION OF THE RADIATION RESISTANCE OF TRANSMITTING AERIALS.— B. V. Braude. (*Izvestiya Elektroprom. Slab. Toka*, No. 4/5, 1940, pp. 12–16.)

The main difficulty in determining the radiation resistance of transmitting aerials is the calculation of the induced resistances of conductors of different length and arbitrarily disposed in space. In this paper a simplified method is proposed in which each aerial conductor is divided into a number of elementary dipoles and the induced resistances are then calculated by the comparatively simple method of induced electromotive forces. Moreover, it is shown that if the conductor length does not exceed one half of the wavelength, it can be replaced with sufficient accuracy by one dipole only. It is claimed that the error of the method does not exceed 10%.

2383. THE CALCULATION OF THE CURRENT IN AN AERIAL DUE TO A DISTRIBUTED ELECTROMOTIVE FORCE.—G. S. Ramm. (*Izvestiya Elektroprom. Slab. Toka*, No. 4/5, 1940, pp. 20–23.)

A method is proposed for calculating the current through a given section of an aerial conductor due to an electromotive force distributed in accordance with a certain law along this conductor. The method is based on the principle of reciprocity, and a formula (3) is derived for determining the current. The method is also applied to a discussion of the following: (a) coupling resistance of two aerial conductors, (b) current distribution along a vertical aerial loaded at the top with an impedance, and (c) equivalent circuit of a receiving aerial.

2384. TRANSMISSION LINES AS REACTORS IN ANTENNA CONSTRUCTION.—V. J. Andrew. (*Communications*, April 1943, Vol. 23, No. 4, pp. 28 and 50.)

The inductive loading of a small vertical radiator, at a point half-way or more up, encounters the difficulties that the inductance must be of very high " Q " if the power losses in it are not to cancel all the theoretical gain due to that loading, and that the mechanical difficulties of construction of a suitable inductance of high " Q " are considerable. The present plan was adopted for the 500 ft tower at WBBM and was so successful that it was applied later to WABC. Various interesting further possibilities of the method are discussed, and the use of transmission lines as reactances is also dealt with in connection with the carrying of various circuits past the base insulator without short-circuiting the latter, and with feeding a f.m. aerial mounted at the top of the WSBT standard broadcasting tower aerial.

2385. CHARACTERISTIC FUNCTIONS OF TRANSMISSION LINES [Illustrated Tabulations of Various Types].—Frankel. (*See* 2304.)

2386. MECHANICAL MODELS OF OVERHEAD LINES [Writer's Theory of Models solves Problems difficult to deal with by Calculation].—G. Hunziker. (*Bull. de l'Assoc. Suisse des Élec.*, 6th May 1942, Vol. 33, No. 9, pp. 242–246: in French.)

VALVES AND THERMIONICS

2387. DEVELOPMENT OF MICRO-WAVE GENERATORS OF THE " TRANSATOR " AND " TURBATOR " TYPE.—Lüdi: Tank. (*See* 2352.)

2388. THE PLOTTING OF POTENTIAL FIELDS WITH THE ELECTROLYTIC TROUGH [including Application to a Retarding-Field Valve].—F. W. Gundlach. (*Funktech. Monatshefte*, No. 4, 1941, p. 49 onwards.) For a long summary see *Bull. de l'Assoc. Suisse des Élec.*, 11th March 1942, Vol. 33, No. 5, pp. 133–135 : in German.

2389. Frequency-Conversion for Decimetric Waves with the Help of Diodes [and a Special Philips Diode for This Purpose].—Strutt & van der Ziel. (*See* 2362.)

2390. Ceramic developed for Tube Bases [Westinghouse " Prestite " now being used by Heintz & Kaufman for Bases for High-Frequency Valves].—(*Communications*, April 1943, Vol. 23, No. 4, p. 65 : paragraph only.) *See* also 1339 of 1942.

2391. Fluctuation Phenomena in Amplifier Circuits [Survey, including Valves employing Secondary Emission].—Bakker. (*See* 2321.)

2392. Contribution to Our Knowledge of the Fundamental Process of Secondary-Electron Emission.—K. H. Geyer. (*Ann. der Physik*, 7th Feb. 1943, Vol. 42, No. 5, pp. 337–347.)

" Experimental results have led to the conclusion that the fundamental process of secondary-electron emission is to be regarded as an interaction of the primary electron with an atom as a whole, and that it occurs after a loss of velocity of the primary electron (ref. " 1 " [Lenard, " Quantitative data on cathode rays of all velocities," 1925]). On the other hand, all previous theoretical works based on wave-mechanical considerations (Fröhlich, 1932 Abstracts, p. 658, r-h column : Wooldridge, 147 of 1940) take only an electron/electron collision as the starting point of the calculations, on the grounds probably of the scanty variation-possibility in the observation of secondary emission, so that calculation is not provided by experiment with sufficiently precise assumptions. Thus measurements of secondary emission show directly two dependences only, that of the quantity of secondary electrons (SE) on the primary energy, and the energy distribution of the SE. There are lacking, therefore, variants to represent, first, the course of the propagation of the primary electrons in the medium ; secondly, the releasing process and the path of the SE ; and finally the influence of the outer boundary surface. In the following paper a further statement is announced on the fundamental process of SE emission : it is derived from experimental data," taken from the works of Bruining & de Boer (982 of 1938 and 549 of 1939), Copeland (ref. " 2 ") : Warnecke (139 of 1935 and 990 of 1937) : Sixtus (1930 Abstracts, p. 160) : and the present writer (2594 of 1940 ; 1974 of 1942 ; and 1119 of April).

Author's summary :—" (1) The analysis of the secondary-electron output curve $\delta = f(U)$ is employed to obtain details of the process of secondary-electron emission. In the energy region from about 50 volts up to approximately the optimum velocity, the differential quotient [$\partial = d\delta/dU$: *see* Fig. 1b, where ∂ is plotted against U] of the output curve is closely representable by an exponential curve. (2) The value of ∂ at the point $U = 0$ [∂_o, the slope of the initial part of the output curve] is seen to be independent of the depth of penetration of the primary electrons and of the surface-condition of the secondary-emitting material. But it is unequivocally dependent on the principal quantic number n of the outermost electron shell of the emitting atom. (3) The conclusion, already expressed by Lenard, is reached that the atom as a whole takes up energy from the primary electrons and conveys it, through an intermediary mechanism, to the most easily separable electron, which escapes as a secondary electron. $\phi_s = 1/2\partial_o$ is the limiting value of the velocity-loss of the primary electron for decreasing primary energy." This last result is obtained with the help of Maurer's theoretical work, 68 of January : Maurer obtains the equation of the output curve from statistical quantities related to the continuum of the secondary-emitting substance, again for the region of the function 1 of Fig. 1b (*i.e.* from about 50 v to near the optimum velocity), without making any assumptions as to the releasing process of the secondary electrons. The differentiation of Maurer's equation gives, at the point $U = 0$, the value $\partial_o = 1/2\phi_s$, where ϕ_s is the energy of formation of a secondary electron ; that is, the amount taken from the primary electron, and not the ionisation potential of the emitting atom. Hence the above result regarding the significance of ϕ_s. Fig. 4 gives values for this quantity between 15 v for $n = 2$ and 130 v for $n = 6$. This loss of velocity, which has the same value for equal values of n, is thus characteristic of an intermediary mechanism which transfers to an electron of the outer shell the energy necessary for its escape.

The author's summary ends as follows :—" (4) The prospect is envisaged that this intermediary mechanism may be explored through an investigation of the rare earths [in which series " the systematic filling of the 4*f*-electrons has already yielded much information on the structure of the atom "]. By the present method it is also possible to derive further quantitative knowledge about slow electron rays " [by the use of deposited films of known, increasing thicknesses, as already studied by the writer].

2393. Effect of High-Frequency Voltage on Dielectric Constant of Space containing Electrons [Question of Applicability of Eccles – Larmor Expression]. — S. Ghosh. (*Current Science* [Bangalore], Feb. 1943, Vol. 12, No. 2, pp. 53–54.)

Khastgir & Choudhury found the dependence of the dielectric constant of the medium inside a valve on the impressed h.f. voltage which had already been noted by Prasad & Verma, but did *not* confirm the parabolic relation observed by these workers between the change of capacitance of the experimental condenser and the magnitude of the voltage (*see* 92 of 1941) : " Khastgir suggested that the observed effect was due to the fact that the effect of h.f. voltage is to alter the amplitude of the electrons in the anode/screen-grid space," so that with gradually increasing voltage the equivalent shunt resistance would gradually fall and then, after some time, come to a constant value. The present writer has repeated the Prasad–Verma experiments, with some improvements taking conductivity corrections into account. He obtains no parabolic variation, his curves being essentially of the same type as those of Khastgir & Choudhury: a typical graph ($\lambda = 110$ m) is given in Fig. 1. The increase of anode current with increasing h.f. voltage is seen in Fig. 2: comparison of Figs. 1 and 2 shows that the thermionic current begins to assume a constant value at that h.f. voltage where the change in capacitance also tends to become constant. Fig. 3 shows the relation between the change of capacitance and the change of thermionic current: "the figure reveals that, at least partially, the observed change in capacitance is due to change in electronic concentration consequent upon the introduction of h.f. voltage": it is an effect of secondary nature.

2394. Noises due to the Type CL4 Valve: a Note on Krebs's Communication [781 of March].—H. Jockusch: Krebs. (*Funk* [Berlin], 1st/15th Oct. 1942, No. 19/20, p. 272.)

Noises due to valves, particularly output valves with grid caps, have troubled the writer also, and he has tried to eliminate them by subsequent soldering of the lead to the cap. The old trouble, however, returned—usually very soon. Investigation showed that the cause of the defective junction was the air enclosed in the cap: on cooling it contracts, sucks the not-yet solidified tin inwards, and prevents a satisfactory connection. But when the soldering has been done after an air-hole has been made in the side of the cap with a file, the noises have been cured apparently permanently in all the 20 cases already tried. "The industry may be recommended to provide a small air-hole in the grid cap."

2395. "Tips on making Transmitting Tubes Last Longer" [Notice of Booklet, for Industrial Field as well as Broadcasting].—R.C.A. (*Journ. Applied Phys.*, May 1943, Vol. 14, No. 5, p. xiv.)

2396. Glass Strain: a Simple Method that can be used in Factories for determining and analysing Glass Strains in Electronic Tubes and Other Glass Forms [Technique using Open-Polaroids Polariscope: Application to Seal-Off Tips, Pinch-Seals, etc.].—H. J. Nolte. (*Gen. Elec. Review*, May 1943, Vol. 46, No. 5, pp. 275–280.)

2397. Simpler Valves [Agreement with "Diallist's" Suggestion: the Valve-Holder Basis of Royalty as the Original Reason for Adoption of Multiple Valves].—A. A. Turney: "Diallist". (*Wireless World*, July 1943, Vol. 49, No. 7, pp. 219–220.) *See* 2146 of August.

2398. *Wireless World* Brains Trust: International Valve Standardisation.—F. Langford-Smith. (*Wireless World*, July 1943, Vol. 49, No. 7, p. 206.)

2399. Historic Firsts: the High-Vacuum Electronic Tube [Arnold's First High-Vacuum Valve, used as Telephone Repeater in 1913].—H. D. Arnold. (*Bell Lab. Record*, May 1943, Vol. 21, No. 9, p. 283.)

DIRECTIONAL WIRELESS

2400. Wireless Equipment of the Enemy Air Forces [Illustrated Survey of Polish, French, British, & Russian Apparatus, with Critical Comments].—G. Hepcke. (*E.T.Z.*, 5th Nov. 1942, Vol. 63, No. 43/44, pp. 505–510.)

2401. Aircraft Compass Calibration [Causes of Deviations: General Deviation Characteristics encountered: Procedure for determining Value of Deviations: Mechanical Means of applying Compensating Correction Factors: Calibration Methods: Ground Checking Methods: etc.].—C. W. McKee. (*Communications*, March 1943, Vol. 23, No. 3, pp. 9–12 and 54, 55, 66–68, 70, 79.) Concluded in April issue, No. 4, pp. 46 and 48. The writer is Supervisor of Aircraft Radio, Eastern Air Lines.

2402. Leader Cables [Study of Magnetic Field of a Cable in Neighbourhood of Ground: Field of a Leader Cable, and Its Polarisation: Reception on Board: Elimination of False Cables: etc.].—F. Raymond. (*Rev. Gén. de l'Élec.*, Dec. 1941, Vol. 50, No. 6, p. 393 onwards.) With 16 diagrams. Referred to in *Bull. de l'Assoc. Suisse des Élec.*, 17th June 1942, p. S27.

ACOUSTICS AND AUDIO-FREQUENCIES

2403. The Electrical Amplifying Stethoscope and Phono-Electrocardioscope.—Donovan. (*See* 2606.)

2404. The Freely Oscillating Piston Diaphragm [Analysis of the Vibration of a Circular Plate oscillating as a Rigid Structure, Not (as usual) Set into a Rigid Wall but radiating into Free Space].—A. Sommerfeld. (*Ann. der Physik*, 7th Feb. 1943, Vol. 42, No. 5, pp. 389–420.)

For the diaphragm set into the wall, and for sufficiently small, harmonic oscillations, the equations are: (1) $\Delta\phi + k^2\phi = 0$ for $z > 0$, (2) $-\partial\phi/\partial z = v$ for $r < a$ and $z = 0$, and $-\partial\phi/\partial z = 0$ for $r > a$ and $z = 0$: where a is the plate radius, v the constant amplitude, at the plate, of the plate velocity, $\phi \exp. (-i\omega t)$ the velocity potential, ω and c the angular velocity and the velocity of sound, and k the wave number, ω/c. On the other hand, for the freely vibrating diaphragm eqn. 2 must be replaced by (2′) $-\partial\phi/\partial z = v$ for $r < a$ and $z = 0$, and $\phi = 0$ for $r > a$ and $z = 0$. This last condition is explained on pp. 389–390.

"The built-in diaphragm has been dealt with many times in the past few years and exhaustively represented by H. Stenzel (in his book [3048 of 1940] and in the paper dealt with in 2707 of 1942). The freely oscillating diaphragm, on the contrary, has been left practically untouched. The reason is the following: in the first case there is a general method, applicable even to arbitrarily bounded diaphragms, available for representing the sound-field by an exact formula: in the second case this method fails even for a circular boundary of the diaphragm. The method in question is that of Green's function. Since this appears to be insufficiently known to acoustical engineers and is not, so far as I can ascertain, explicitly mentioned by Rayleigh even though his often-quoted formula (eqn. 3, § 278 of the " Theory of Sound ": eqn. 8a, p. 392 of the present paper) is founded on it, it may well be described briefly here ": this is done in § 2, where it is shown that neither form of Green's equation, eqns. 8a and b, is applicable to the case of the freely oscillating diaphragm: " we have to do, here, with a ' mixed ' type of boundary conditions, requiring a ' mixed ' Green's function . . ."

King's method (1934 Abstracts, p. 622, r-h column), which is based on the present writer's wireless telegraphy equation (eqn. 10) is described in § 3: " it is elegantly practicable for the diaphragm set into a wall, but even here it gives no simpler results than the Green–Stenzel method. In connection with an investigation of the Rayleigh disc (638 of 1936), King tried to solve the integral equations for $f(\lambda)$, eqn. 11b, reached when applying this method to the freely oscillating diaphragm, by the use of successive approximations; but he got no further than the two first steps owing to the complexity of the calculations. " On the other hand, we shall in the following pages introduce a procedure which leads, in a certain sense, to the complete solution. This procedure consists in forming an expression for $f(\lambda)$ having an infinite number of arbitrary coefficients and satisfying the second equation 11b, and then determining these coefficients in such a way that the first equation of 11b is also satisfied."

This method is followed from § 4 onwards, and at the top of p. 409 the required approximate expression is arrived at for obtaining the coefficients $A_1 \ldots A_n$ of eqn. 13; this agrees with eqn. 34 of King's paper, already mentioned, except that the latter equation omits the higher terms, in α^2 and $\alpha^{5/2}$. Knowing these coefficients, eqns. 10, 12, 13 now give eqn. 69 for ϕ for $r < a$ and $z = 0$, and " since it has been ensured in § 4 " [and *see* eqn. 2′ of § 1] that ϕ vanishes for $r > a$, ϕ is now known throughout the whole plane $z = 0$. " Our original problem of ' mixed ' type is thus brought back to the single type of the relation 8b " [the second of the two Green's equations referred to above].

In § 10 the writer departs from the condition $z = 0$ and examines the sound field in the neighbourhood of the piston diaphragm, using in the first place cylindrical polar coordinates and obtaining, by the use of eqn. 69 (just derived) and his own early Hertz-dipole equation, a final eqn. 72 for the sound field. The first integral in this, however, is extremely complicated, and in § 10 the writer turns to the spherical polar coordinates usually employed in acoustics. Again making use of eqn. 69 he obtains eqn. 75 for the sound field: this is only useful for $r > a$. In § 11 the development of the sound field in powers of α ($\alpha = (ka/2)^2$, eqn. 29b) is carried out, in order to make the formulae already obtained susceptible to calculation. " All our approximations apply to the case of long waves and not too great diaphragm-radii ": for supersonic waves or very large diaphragms they fail, and recourse must be made to the expressions originated by Rubinowicz and applied to the problem of the built-in diaphragm by Schoch (*Akust. Zeitschr.*, Vol. 6, 1941, p. 318 onwards) and Stenzel (2707 of 1942): their application to the freely oscillating diaphragm requires further work which is not dealt with here.

2405. Characteristics of High-Fidelity Systems [Radio Broadcasting, Recording: Analysis of Requirements & Performance of the Component Stages].—A. J. Ebel. (*Communications*, April & May 1943, Vol. 23, Nos. 4 & 5, pp. 38–40 and 42, 44, & pp. 24..28 and 62..71.)

(i) " To summarise, an electroacoustic transmission system which will pass all frequencies uniformly from 20 to 15 000 cycles, and will have a linear response over the range of 75 db within 1% distortion, critical damping or greater, and an r.m.s. noise level, over-all, better than 75 db below peak level, will faithfully reproduce all sound waves in the electro-acoustic transducer that are applied to the acousto-electric transducer." The question of transient response is discussed briefly: " the possibility that resonant equalisers could have a decrement of such value to be noticeable might account for the splattering ' s ' sounds on some highly equalised recordings." (ii) " Many radio programmes are designed for a below-average intelligence level. . . . A transmission system to be used for background accompaniment should not transmit frequencies above 4000 cycles and should have a limited dynamic range, and should have little noise or distortion. . . . Where the listener concentrates on the presentation, the demand for fidelity goes up. It is this problem which receiver manufacturers have wrestled with for years and which has made the tone control a standard component of all receivers, even those designed for high fidelity." Nevertheless, " the present demand for high fidelity is definitely on the up-grade ": a General Electric pamphlet, " What the Consumer Thinks of FM," is quoted here.

2406. The Siemens Silver-Vapour Process for Gramophone-Record Production [Deposition complete in 30 Seconds: No Damage to Wax Record from 1200° Temperature of the Vapour: Advantages over Sputtering Process].—Siemens & Halske. (*Bull. de l'Assoc. Suisse des Élec.*, 5th May 1943, Vol. 34, No. 9, p. 263: in German.)

2407. Glass Discs for Use in Home and Commercial Sound Recorders.—H. & A. Selmer. (*Scient. American*, May 1943, Vol. 168, No. 5, p. 228.)

2408. Gramophone Record Wear [takes place on Inner, Not Outer Side of Groove].—R. Boorman: G. E. Horn & R. H. Thrussel. (*Wireless World*, July 1943, Vol. 49, No. 7, p. 219.) Prompted by 2161 of August.

2409. Play your Gramophone Records properly! [Comparison of Various Types of Pick-Up, with Hints on Correct Tracking and on Tone-Correcting Circuits]. — H. Ebel. (*Funk* [Berlin], 1st/15th Oct. 1942, No. 19/20, pp. 253–257.)

2410. Pick-Up Coupling Transformer: Practical Design for Use with Moving-Coil Pick-Ups.—J. Brierley. (*Wireless World*, July 1943, Vol. 49, No. 7, pp. 212–213.) Following on 3020 of 1942 [*see* also 78 of January and 1707 of June].

2411. Recording Telephone Conversations: an Inexpensive Amplifier for Use with Office Dictating Machines.—G. Grammer. (*QST*, May 1943, Vol. 27, No. 5, pp. 34–36.)

2412. Conference Control made Possible by New Intercommunication System [" Super-Chief," with " Many New Features "].—(*Scient. American*, March 1943, Vol. 168, No. 3, p. 131.)

2413. New Method of Teaching: " Synchrophone " as Mechanical Aid to Technical Instruction.—N. Sandor. (*Electrician*, 2nd July 1943, Vol. 131, No. 3396, pp. 19–20.)

2414. Sound-on-Film: New Recorder operates for Eleven Hours [Surface-Indentation Principle with Immediate Play-Back: the " Filmgraph "].—(*Scient. American*, May 1943, Vol. 168, No. 5, p. 225.)

2415. The Sound Head [in Sound-Film Reproduction: Historical Development: Mechanical Design (particularly the Causes & Elimination of Flutter): Optical Design: Electronic Requirements].—R. H. Cricks. (*Electronic Eng:g*, May 1943, Vol. 15, No. 183, pp. 496–500.)

2416. A Pre-Amplifier for the Home Sound-Film Installation [to enable an Ordinary Broadcast Receiver to be used for the Reproduction of the Sound Track].—G. Froboess. (*Funk* [Berlin], 1st/15th Oct. 1942, No. 19/20, pp. 273–274.)

2417. The Correct Method of Connection of Mixer Controls [for the Mixing and Fading-Out of Two or More Microphone or Gramophone Items: Defects of the Simple Method: a Perfected Arrangement].—(*Funk* [Berlin], 1st/15th Oct. 1942, No. 19/20, p. 274.)

2418. Contribution to the Acoustics of Radio Studios.—W. Furrer. (*Journ. Acous. Soc. Am.*, April 1943, Vol. 14, No. 4, Part 1, pp. 239–241.) Long summary of the Swiss work dealt with in 3286 of 1942 and back reference.

2419. The Acoustics of Broadcasting Studios.—W. Furrer. (*Bull. de l'Assoc. Suisse des Élec.*, 3rd June 1942, Vol. 33, No. 11, pp. 305–310: in French.) A long paper, in German, was dealt with in 3026 & 3286 of 1942: *see* also 2418, above.

2420. Review of Acoustical Patents [Regular Feature].—R. W. Young. (*Journ. Acous. Soc. Am.*, April 1943, Vol. 14, No. 4, Part 1, pp. 244–253.)

2421. Wave Analysis: Part III.—Analysis of Periodic Wave-Forms (Concluded).—K. Bourne. (*Electronic Eng:g*, June 1943, Vol. 16, No. 184, pp. 31–36.) Continued from 2015 of July: it surveys the heterodyne methods covering the broad field of " search-tone " or " exploring-note " analysis. There are 52 literature references.

2422. An Experimental Study of the Tone Quality of the Boehm Clarinet.—C. S. McGinnis, H. Hawkins, & N. Sher. (*Journ. Acous. Soc. Am.*, April 1943, Vol. 14, No. 4, Part 1, pp. 228–237.)

2423. Pressure Variation of Pitch of a Flute Pipe [of Importance in Standardisation and for Performer].—K. Ray. (*Sci. & Culture* [Calcutta], April 1943, Vol. 8, No. 10, pp. 425–426.)

2424. Electronic Tuning of Musical Instruments by Unskilled Persons: the American "Resonoscope," etc.—(*See* Discussion of Reyner's paper dealt with in 2578, below.)

2425. Bone-Conduction Threshold Measurements: Effects of Occlusion, Enclosures, and Masking Devices.—N. A. Watson & R. S. Gales. (*Journ. Acoust. Soc. Am.*, April 1943, Vol. 14, No. 4, Part 1, pp. 207–215.)

2426. Bomb Scoring made More Accurate by Microphone Method [at Bombardier College: " Sonic Method " developed from Seismic Prospecting Technique].—E. P. McKaba. (*Scient. American*, March 1943, Vol. 168, No. 3, pp. 128–129.)

2427. An Under-Water Sound of Natural Origin [attributed by Local Fisherman to Toadfish Gnashing Their Teeth].—E. O. Hulburt. (*Journ. Acous. Soc. Am.*, Jan. 1943, Vol. 14, No. 3, pp. 173–174.) After discussing various possible causes the writer concludes: " We favour the toadfish theory . . . . but wonder whether toadfish have teeth."

2428. Focused Supersonic Waves from Curved Crystals [Researches at College of Physicians & Surgeons, Columbia University].—J. G. Lynn & others. (*Scient. American*, March 1943, Vol. 168, No. 3, p. 115.)

2429. Application of Supersonics in Metallurgy.—(*See* 2569.)

PHOTOTELEGRAPHY AND TELEVISION

2430. ON THE STANDARDISATION OF TELEVISION CONSTANTS.—I. S. Dzhigit. (*Izvestiya Elektroprom. Slab. Toka*, No. 3, 1940, pp. 2–14.)

A comparative study is made of the standardisation in various countries (U.S.A., G.B., France, Germany, and U.S.S.R.) of television constants such as the number of lines per frame, frame frequency, method of scanning (progressive or interlaced), transmission of the d.c. component, waveform of synchronising impulses, polarity of transmission, etc.

2431. ON INTERFERENCE IN TELEVISION TRANSMITTING SYSTEMS.—V. I. Krasovski. (*Izvestiya Elektroprom. Slab. Toka*, No. 3, 1940, pp. 14–26.)

The following sources of interference in television transmitting apparatus are discussed: fluctuations of primary and secondary electron currents, fluctuations of the electron beam with a strong space charge at the thermocathode, fluctuations due to the mosaic structure of the electrode (metallic electrode covered at random with grains of another metal), thermal fluctuations in the amplifier resistances, and anode-current fluctuations of the amplifier valves. Methods are indicated for estimating the above fluctuations. Some numerical examples are given and a short report on an experiment investigation is included. Methods for reducing some of the above fluctuations are also suggested.

2432. ON THE FLUCTUATION INTERFERENCES IN PICTURE TRANSMISSION AND TELEVISION.—A. M. Khalfin. (*Izvestiya Elektroprom. Slab. Toka*, No. 3, 1940, pp. 27–34.)

A mathematical discussion is presented of the distortion of the received image due to fluctuations in the signal current (or voltage). It is shown that the average number of image elements in which the fluctuation interference of a given value can be observed is proportional to the probability of the appearance of the interference at this point. A method based on the physiological properties of the eye is proposed for calculating the mean-square value of the interference level at which the interference ceases to be seen. It is also shown that the necessary signal/interference ratio determined experimentally for a given system may not hold good for another system with a different source of interference and a different distribution of probabilities.

2433. THE TRANSMISSION OF LOW FREQUENCIES BY THE METHOD OF D.C. WORKING.—O. B. Lur'e. (*Izvestiya Elektroprom. Slab. Toka*, No. 3, 1940, pp. 35–40.)

The transmission of the d.c. component and of very low frequencies is effected by fixing the density of black at the end of each line of the television signal, *i.e.* by producing sections in which the voltage corresponds to a definite density of black or differs from it by a definite amount. This fixation is upset when the signal passes through a resistance-capacitance-coupled amplifier and subsequently restored at another point of the television channel. The possibility of using this method for transmitting frequencies higher than the frame frequency is investigated theoretically in this paper. Various circuits involved are discussed and it is shown that frequencies up to about 1000 c/s can thus be transmitted.

2434. TELEVISION RECEIVER TYPE T 13.—A. A. Raspletin. (*Izvestiya Elektroprom. Slab. Toka*, No. 3, 1940, pp. 41–46.) Description, with circuit diagrams, of a television receiver developed in Russia in 1939.

2435. THE ULTRA-SHORT-WAVE RECEIVER WITH DIRECT AMPLIFICATION. — V. K. Kenigson. (*Izvestiya Elektroprom. Slab. Toka*, Nos. 3 & 4/5, 1940, pp. 46–57 & 48–52.)

Formulae are derived for the design of the input circuit and of the amplifier (operating at the incoming-signal frequency) of a television receiver. The formulae are applied to the design of the type T 13 receiver (2434, above) and experimental data obtained in testing this receiver are given.

2436. A TELEVISION RECEIVER WITH A 1 M × 1.2 M SCREEN (TYPE TE-2).—I. M. Zavgorodnev. (*Izvestiya Elektroprom. Slab. Toka*, No. 3, 1940, pp. 57–60.) A description of a receiver suitable for audiences of from 100 to 150 people.

2437. A CATHODE-RAY TUBE FOR TELEVISION RECEIVERS. — K. Yanchevski. (*Izvestiya Elektroprom. Slab. Toka*, No. 3, 1940, pp. 60–64.) With electrostatic focusing and magnetic deflection, a screen 110 mm in diameter, and an accelerating voltage around 12 000 v. A number of characteristic curves are plotted.

2438. THE DEFLECTING STAGE OF THE STANDARD POPULAR TELEVISION RECEIVER TYPE E1 [with Deflecting Valve Type ES111].—J. E. Scheel & R. Urtel. (*Telefunken-Röhre*, Aug. 1941, No. 21/22, p. 177 onwards.) With 21 diagrams. *See* also 1441 of 1941 and back reference: and *cf.* Mulert & Rudert, 1440 of 1941.

2439. THE TRANSMISSION CHARACTERISTICS OF ASYMMETRIC-SIDEBAND COMMUNICATION NETWORKS: PART 2.—Cherry. (*See* 2323.)

2440. VIDEO-AMPLIFIER LOW-FREQUENCY CORRECTION [for Deviations due to the Grid-Coupling Circuit acting as *RC* Voltage-Divider across Load Circuit]: AN ANALYSIS OF PLATE-FILTER COMPENSATION.—W. A. Lynch. (*Communications*, April 1943, Vol. 23, No. 4, pp. 16–21, 50, 72, 78 and 79.)

Leading to conclusions which " serve as a simple and accurate guide to correct design," whenever the conditions are fulfilled that fixed bias and screen voltages are employed, that the plate load impedance is very much smaller than the valve resistance, and that the grid resistor of the following stage is very much larger than the plate load: the second and third assumptions are generally fulfilled in wide-band pentode amplifiers.

2441. Television Progress.—A. N. Bhattacharya: Mitra. (*Sci. & Culture* [Calcutta], April 1943, Vol. 8, No. 10, pp. 393–397: to be concluded.) Based on a lecture by S. K. Mitra.

2442. Stereoscopic and Colour Television [Baird's Use of the Anaglyphic Method: the Action of the Converging Lens in His Discless System: etc.].—N. W. M: D. A. Bell. (*Wireless World*, July 1943, Vol. 49, No. 7, pp. 220–221.) Remarks prompted by D. A. Bell's letter in the March issue.

2443. Third Dimension: Effect obtained with Conventional Movie Camera [by use of the "Swing Mount"].—E. H. Bickley. (*Scient. American*, June 1943, Vol. 168, No. 6, p. 266.)

2444. Technical Conditions for Apparatus and Appliances for the Electrical Reproduction of Sound and Pictures, etc.—A.S.E. (*See* 2579.)

2445. Wire Transmission of News Pictures [particularly the International News Photos' Modern Transceiver & Associated Equipment: Future Developments (Frequency-Modulation U.S.W. Links: Direct Engraving)].—J. R. Hancock & F. T. Turner. (*Proc. Radio Club of Am.*, Dec. 1942, Vol. 19, No. 2, pp. 19–27.) No synchronising currents are sent over the line, synchronisation being accomplished by having a standard-frequency generator at each end.

2446. Data Sheet No. 50: Spectral Response Curves [including Lamps, Phosphors, Photocathodes, etc.].—(*Electronic Eng:g*, May 1943, Vol. 15, No. 183, pp. 509–511.)

2447. The Spectral Response of Photoelectric Cells [with Many Curves of Colour Sensitivities for Various Cathodes, including the Baird Type A (Antimony) & Type B (Bismuth), and Their Advantages for Particular Purposes].—T. M. C. Lance. (*Electronic Eng:g*, May 1943, Vol. 15, No. 183, pp. 501–504.) From Cinema Television, Ltd.

2448. A Table of American Photocells.—R.C.A. (*Electronic Eng:g*, May 1943, Vol. 15, No. 183, p. 525.)

2449. R.C.A. 931 High-Vacuum Multiplier Photocell [Diagrams & Technical Data].—R.C.A. (*Electronic Eng:g*, May 1943, Vol. 15, No. 183, p. 530.) *See* also 1130 and 3426 of 1941.

2450. Some Measurements on Selenium Photocells [by a Procedure giving Results freer from Accidental & Secondary Influences: Further Development of 2013 of 1942].—G. A. Veszi. (*Electronic Eng:g*, May 1943, Vol. 15, No. 183, pp. 505–506.)

MEASUREMENTS AND STANDARDS

2451. Using High Crystal Harmonics for Oscillator Control [for Ultra-High Frequencies].—I. E. Fair. (*Bell Lab. Record*, April 1943, Vol. 21, No. 8, pp. 237–242.)

"Oscillators for a large part of the u.h.f. range have thus been forced to employ harmonic generators, since the 5th harmonic of the thinnest usable crystal is only about 50 Mc/s [and for harmonics much above the 5th the reactance remains negative throughout its entire range, whereas "practically all the circuits used for quartz-crystal oscillators require that the reactance of the crystal be positive at the operating point"]. This situation has now been changed by a [lattice-network] circuit developed in these Laboratories which permits crystal harmonics at least as high as the 23rd to be used for direct control of an oscillator circuit. Oscillators have been built for frequencies as high as 150 Mc/s, using crystals with fundamental frequencies below 10 Mc/s," and occupying a very small space (Fig. 10).

2452. "The Mathematics of the Physical Properties of Crystals" [Review of 72 pp Bell System Pamphlet].—W. L. Bond. (*Communications*, April 1943, Vol. 23, No. 4, pp. 70–71.) "Presents a most thorough analysis of a product that is unusually vital to communications to-day."

2453. The Saw-Room in Crystal Production, and the Vital Rôle It Plays [Step-by-Step Description of Procedure, with Illustrations of the Apparatus used].—L. A. Elbl. (*Communications*, March 1943, Vol. 23, No. 3, pp. 13–15 and 62, 77.) From the Crystal Products Company.

2454. Discussion on "The Technique of Frequency Measurement and Its Application to Telecommunications" [1185 of April].—J. E. Thwaites & F. J. M. Laver: F. R. Stansel. (*Journ. I.E.E.*, Part III, June 1943, Vol. 90, No. 10, pp. 73–74.)

Stansel writes: "The authors . . . imply that in the use of Lissajous' figures it is necessary to determine the exact ratio by a detailed inspection of the pattern, which necessarily becomes more difficult as the ratio increases. For many cases, particularly in the calibration of oscillators, the exact ratio may be determined by other means and the pattern used only to establish the exact point at which the frequency is n times the standard . . . Experienced operators generally prefer not to use any phase-splitting circuit or other means of eliminating the back trace, as this relative motion of the fore and back traces greatly increases the accuracy and speed with which the exact point of syntonisation can be recognised . . . As to the frequency range in which Lissajous' figures are useful, it is much wider than the authors imply. I have frequently calibrated against a 1 kc/s standard in the frequency range of 1 to 2 Mc/s and have used a 100 kc/s standard for calibrating at frequencies as high as 25 Mc/s. I have described a variation of the Lissajous' figure method [2455, below] . . . which has proved quite practical in certain measurements in which it is desired to measure frequency with an accuracy of ± 1 c/s at points up to 2 Mc/s . . . We have found regenerative frequency dividers operating with a 10 to 1 ratio entirely practical": he cites Weber's paper, 1187 of April. There seems to be no obstacle to the operation of such a circuit at frequencies at least up to 25 or 50 Mc/s. He points out an error in sign in the original paper: the writers in their reply give the full correction.

2455. AN INTERPOLATION METHOD FOR SETTING LABORATORY OSCILLATORS.—F. R. Stansel. (*Bell Lab. Record*, Nov. 1940, Vol. 19, No. 3, p. 98 onwards.) Referred to in 2454, above.

2456. *RC* GENERATORS [Paper from the Rohde & Schwarz Laboratories].—Bucher. (*See* 2333.)

2457. D.C. VOLTAGE TESTER: A WIDE-RANGE INSTRUMENT WITH HIGH INPUT RESISTANCE [Advantages of the Potentiometer Voltage Balance Device: Description of Complete Instrument with Cathode-Ray Tuning Indicator as Balance Indicator].—T. A. Ledward. (*Wireless World*, July 1943, Vol. 49, No. 7, pp. 202–204.)

2458. A METHOD OF DETERMINING BIOLOGICAL INTER-ELECTRODE IMPEDANCES [Constant-Current Method].—Saunders. (*See* 2607.)

2459. A HIGH-VOLTAGE RADIO-FREQUENCY VOLTMETER.—Bell Tel. Laboratories. (*Electronic Eng:g*, June 1943, Vol. 16, No. 184, p. 13.) *See* 1719 of June.

2460. THE ELECTROSTATIC VOLTMETER AS A D.C./A.C. TRANSFER INSTRUMENT [and the Errors due to Departure from Unity of the D.C./A.C. Sensitivity Ratio, traced to Semi-conducting Films on Surfaces of Voltmeter Elements: Cleaned Platinum Surfaces appear to give Ratio practically Unity: Tests on Air-Core Dynamometers].—R. S. J. Spilsbury & A. Felton. (*Journ. I.E.E.*, Part II, April 1942, Vol. 89, No. 8, pp. 129–132: Discussion pp. 133–136.)

2461. CREST VOLTMETER [Type A3: for Ignition-Voltage Measurement, or for Surge Voltages caused by Corona & Surface Discharges during High-Potential Testing of Electrical Equipment].—General Electric. (*Review Scient. Instr.*, April 1943, Vol. 14, No. 4, p. 120.)

2462. MEASUREMENT OF PEAK VOLTAGES IN HIGH-VOLTAGE TESTING, WITH PARTICULAR REFERENCE TO A MODIFIED DIODE PEAK VOLTMETER [avoiding Errors & Limitations of Previous Methods].—R. N. Buttrey. (*Journ. I.E.E.*, Part II, June 1943, Vol. 90, No. 15, pp. 186–191.)

2463. A PEAK-FACTOR METER FOR ALTERNATING AND DIRECT CURRENT [Combination of Electrostatic Voltmeter & Diode Rectifier].—E. H. W. Banner. (*Journ. I.E.E.*, Part II, Aug. 1942, Vol. 89, No. 10, pp. 369–371.) Complementary to Spilsbury's form-factor meter (279 of 1935).

2464. MEASUREMENT OF DIELECTRIC CONSTANTS AND LOSS ANGLES OF SOLID DIELECTRICS AT RADIO FREQUENCIES.—H. Bender: G. Holzner & G. Gregoretti. (*T.F.T.*, Nov. 1942, Vol. 31, No. 11, pp. 293–298.) German version, by Bender, of the *Alta Frequenza* paper dealt with in 1454 of 1941.

2465. FIELD MEASUREMENTS OF INSULATION [Apparatus & Methods used on the Central Electricity Board's System: including a Modified Schering Bridge with Thermionic Detector, and an Electronic Testing Set for Resistances up to 10 000 Megohms at 5 kV].—E. A. Burton, J. S. Forrest, & T. R. Warren. (*Journ. I.E.E.*, Part II, Aug. 1942, Vol. 89, No. 10, pp. 288–305: Discussions pp. 305–316.)

2466. AUDIO-FREQUENCY SCHERING BRIDGE [Equipment suitable for 20–6000 μμF and Power Factors less than 0.008].—J. W. Snelson. (*Electronic Eng:g*, June 1943, Vol. 16, No. 184, p. 40: summary only, from *Met.-Vick. Gazette*.)

2467. MEASUREMENTS ON IMPULSE VOLTAGES WITH A BALLISTIC GALVANOMETER [and Comparison with Results obtained simultaneously with a High-Speed Cathode-Ray Oscillograph: a Combined Ballistic Crest Voltmeter & Chronometer].—G. W. Bowdler. (*Journ. I.E.E.*, Part II, Dec. 1942, Vol. 89, No. 12, pp. 555–560: Discussion pp. 561–564.) A summary was referred to in 2048 of 1942.

2468. STANDARDS FOR CONDENSERS, EXCLUDING LARGE CONDENSERS FOR POWER-FACTOR IMPROVEMENT [and Electrolytic Condensers].—A. S. E. (*Bull. de l'Assoc. Suisse des Élec.*, 3rd June 1942, Vol. 33, No. 11, pp. 328–331: in French.) Protecting and interference-suppressing condensers.

2469. "A.S.T.M. STANDARDS ON ELECTRICAL INSULATING MATERIALS" [Book Review].—A.S.T.M. Committee. (*Communications*, April 1943, Vol. 23, No. 4, p. 70.) "Covers the 1942 compilation of standards."

2470. STANDARDS OF ELECTRICAL MEASUREMENT [Survey, including Account of the More Recent Experimental Researches of the Standardising Laboratories, and the Present Legal & International Position of Electrical Units, including the M.K.S. System].—L. Hartshorn. (*Journ. I.E.E.*, Part I, Dec. 1942, Vol. 89, No. 24, pp. 526–535.)

2471. STANDARDISATION AND ELECTRICAL ENGINEERING: 25 YEARS OF THE GERMAN STANDARDS COMMITTEE, 50 YEARS OF THE "VERBAND DEUTSCHER ELEKTROTECHNIKER" [with 136 Literature References].—H. Wagner. (*E.T.Z.*, 19th Nov. 1942, Vol. 63, No. 45/46, pp. 529–535.)

2472. Transparent Test Chamber made from Bomber Nose [for Altitude Tests of Radio Equipment: Several Engineers can work Simultaneously: No "Peering" through Small Ports].—R.C.A. (*Sci. News Letter*, 22nd May 1943, Vol. 43, No. 21, p. 331 and Front Cover.)

SUBSIDIARY APPARATUS AND MATERIALS

2473. A Portable Electron Microscope [only 16″ Long, giving (with 20-fold Enlargement) Micrographs with Total Magnification of 100 000].—Zworykin. (*Scient. American*, Feb. 1943, Vol. 168, No. 2, p. 74.)

2474. Electron Microscopy [with Details of Latest R.C.A. Model: Applications: a Simple & Compact Type (16″ Long) for Routine Observations].—Zworykin. (*Electronic Eng:g*, June 1943, Vol. 16, No. 184, p. 40: summary only, from *Electronics*.)

2475. Data Sheet No. 50: Spectral Response Curves [including Lamps, Phosphors, Photocathodes, etc.].—(*Electronic Eng:g*, May 1943, Vol. 15, No. 183, pp. 509–511.)

2476. The Synchronisation of Oscilloscope Sweep Circuits: a Lucid Graphical Analysis.—MacLean. (*See* 2335.)

2477. A Precision Time-Scale Recorder for Loop Oscillographs [using Grid-Controlled Ionic-Valve "Kipp Circuits" in Decade Arrangement].—Krug & Baszel. (*Siemens-Zeitschr.*, Oct./Dec. 1941, Vol. 21, No. 5, p. 177 onwards.) With 14 diagrams.

2478. Amplifying and Recording Technique in Electro-Biology [including the Analysis of Records: Promising Results with Tuned Reeds prolonged into Pens].—Parr & Walter. (*See* 2602.)

2479. An Automatic Low-Frequency Analyser [using Tuned Reeds as Frequency Splitters].—Walter. (*See* 2603.)

2480. Ambient Temperature Recorder [with Special Features eliminating Sticking and giving Very Small Time-Lag: using Differential-Roller Magnifying System with Control by Invar/Nickel-Steel Bimetal Strips].—Sunvic Controls. (*Journ. of Scient. Instr.*, May 1943, Vol. 20, No. 5, pp. 81–82.)

2481. A High-Voltage Plate-Power Supply using Mercury-Vapour Tubes [Unit giving 0.768 A at 1600 V for Station WIS].—Helt. (*See* 2360.)

2482. A Photoelectric Voltage-Control Gear [Voltage on 1 kW Load maintained within ±1 V (and Better) at 240 V: Voltmeter (fitted with Mirror), Two Photocells, Amplifiers, Relays, Reversible Motor, & "Variac"].—Samson. (*Electronic Eng:g*, May 1943, Vol. 15, No. 183, pp. 516–518.)

2483. Voltage Regulation of Variacs and Effects of Substitute Materials.—General Radio. (*Journ. Applied Phys.*, May 1943, Vol. 14, No. 5, p. xii: notice of booklet.)

2484. Vibrator Voltage Regulator [primarily for Aircraft Service: Battery Variation from 20 V to 30 V leaves Voltage on Vibrator between 6.0 V & 6.3 V: Similar Design for Any Loads provided Wattage consumed by Amperite Itself does Not Exceed 40 W].—Amperite Company. (*Communications*, March 1943, Vol. 23, No. 3, p. 56.)

2485. A Clock-Controlled Governor for Close Speed Regulation.—Prescott & Karaosman. (*See* 2583.)

2486. Andrew Gas-Tight Terminal [for Radio Coaxial Cables].—(*Communications*, April 1943, Vol. 23, No. 4, p. 56.) "The unusual seal is obtained by fusion of glass to metal . . ." Paragraph and photograph only.

2487. Glass Strain: Method of determining and analysing Glass Strains in Electronic Tubes and Other Glass Forms.—Nolte. (*See* 2396.)

2488. Light-Weight Thyratron Tube [with Control & Shield Grids: Weight only 2 oz: Small Size: Type GL-502].—General Electric. (*Communications*, March 1943, Vol. 23, No. 3, p. 75.)

2489. Contribution to Our Knowledge of the Fundamental Process of Secondary-Electron Emission.—Geyer. (*See* 2392.)

2490. Surge Flash-Over Measurements on Rod Gaps.—Wanger. (*See* 2313.)

2491. Signal Liquid hardens to a Surface that Melts Sharply [for Temperature Determination: "Tempilaq" Liquid].—(*Scient. American*, March 1943, Vol. 168, No. 3, p. 132.) For the use of such indicators in the testing of u.h.f. insulators *see* 1792 of 1942: and *cf.* 2023 of 1942.

2492. Synthetic Polymerised Resin to supplement Supply of Mica.—(*Science*, 7th May 1943, Vol. 97, No. 2523, Supp. p. 12.)

2493. New Substitute for Rubber [Semi-Plastic from Polyvinyl Alcohol, "Resistoflex," for Flexible Hoses (used in Manufacture of R.C.A. Valves) standing up to Saturation with Hot Oil, and Continuous Flexing, better than Rubber Tubing: Other Uses].—Resistoflex Corporation. (*Journ. Applied Phys.*, May 1943, Vol. 14, No. 5, p. xii.)

2494. A Textile Alternative for Sponge-Rubber ["Resilitex": with Comparison with Sponge-Rubber & Felts].—Lister & Company. (*Journ. of Scient. Instr.*, May 1943, Vol. 20, No. 5, p. 80.)

2495. Foamglas [to replace Cork, Balsa Wood, Cellular Rubber, etc.].—Pittsburgh Corning Corporation. (*Engineer*, 11th June 1943, Vol. 175, No. 4561, p. 476.)

2496. A New Transparent Plastic, "C.R. 39," with Special Properties.—Pittsburgh Plate Glass Company. (*Scient. American*, March 1943, Vol. 168, No. 3, p. 124.)

2497. New Electrical Insulation [" Multiform " Glass Insulators].—Corning Glass Works. (*Journ. Applied Phys.*, May 1943, Vol. 14, No. 5, p. x.) *See* also 1972 of July.

2498. Ceramic developed for Tube Bases [Westinghouse " Prestite "].—(*See* 2390.)

2499. Low-Loss Ceramics [Wet & Dry Pressing Methods, Tolerances: Design Considerations: etc.].—Gillam. (*BEAMA Journ.*, June 1943, Vol. 50, No. 72, p. 197 : summary only.)

2500. Battery Cases now made of Ceramic to conserve Rubber [" Vitrabloc " Batteries with Vitrified Ceramic Cases].—Philco Corporation. (*Scient. American*, April 1943, Vol. 168, No. 4, p. 159.)

2501. The Characteristics and Performance in Service of High-Voltage Porcelain Insulators.—Forrest. (*See* 2375.)

2502. Lignin in Phones: New Insulating Material made from Paper Waste.—Western Electric. (*Scient. American*, Feb. 1943, Vol. 168, No. 2, pp. 84–85.)

2503. Plastic from Jute Waste [with Proposed Name " Jutelite "].—Guha & Das. (*Sci. & Culture* [Calcutta], March 1943, Vol. 8, No. 9, p. 389.)

2504. " A.S.T.M. Standards on Electrical Insulating Materials " [Book Review].—A.S.T.M. Committee. (*Communications*, April 1943, Vol. 23, No. 4, p. 70.) " Covers the 1942 compilation of standards."

2505. Self-Discharge and Time Constant of the High-Voltage Oiled-Paper Condenser.—Brinkmann. (*See* 2351.)

2506. Equivalent Circuit of the Electrolytic Condenser.—Wachenhusen. (*See* 2350.)

2507. Modern Condenser Technique [Paper, Mica, & Ceramic Dielectrics: Electrolytic].—Cozens. (*Journ. British Inst. Rad. Eng.*, March/May 1943, Vol. 3, No. 4, pp. 125–143 : Discussions pp. 143–151.)

Among the points considered are :—" Non-inductive " roll-type condensers, and recent improvements in the " lug-type " condenser which have reduced its inductance to (at most) the same as that of the " extended-foil " type [*see* also replies in Discussions] : " in circuit design, the only paper condensers whose inductance is likely to be of importance are the tubulars," for which a useful approximate rule is given : " a knowledge of the inductance of a condenser may sometimes be usefully employed " to produce an enhanced by-pass effect at a particular frequency, *e.g.* in radio interference filters : paper condensers and a.c., and troubles often encountered with condensers rapidly charged and discharged (*e.g.* in time-base circuits) due to forgetfulness of the resulting a.c. component : power-factor variation with temperature and frequency [in Discussion] : " the idea of coating paper with ceramic powder of high permittivity is attractive, but at present the practical difficulties are considerable " [reply to Alston]. " Recent research has shown that it is possible to make a ceramic body of high permittivity and negative capacity/temperature coefficient which has a good power factor throughout the frequency range from very low audio-frequencies upwards." Electrolytic condensers : examination of the true effect of power factor on smoothing.

2508. A Theory of the Irreversible Electrical-Resistance Changes of Metallic Films evaporated in Vacuum [with Remarks on Sputtered Films].—Vand. (*Proc. Phys. Soc.*, 1st May 1943, Vol. 55, Part 3, No. 309, pp. 222–246.)

2509. Symposium on Powder Metallurgy [Some Summaries, including Papers on Effect of Pressure on the Properties of Compacts and of Particle Size on Their Shrinkage during Sintering (" Inflection Temperatures " for Particles smaller than 200 Mesh)].—Balke, Kalischer, & others. (*ASTM Bulletin*, March 1943, No. 121, pp. 7–9.)

2510. Contact Problems [Definition of " Limiting Current ", and Data for Various Materials : Electrical Conductivity & Its Relation to Thermal : Factors influencing Transport of Contact Material : Powder Metallurgy & Its Products for Contacts : etc.].—Hausner. (*Bull. de l'Assoc. Suisse des Élec.*, 28th Jan. 1942, Vol. 33, No. 2, pp. 29–34 : in German.)

2511. The Simple Construction of Accurate Division Plates, [for Gear Cutting, Scale Dividing, etc : making Use of Ball-Bearing Balls, obtainable in Selected Batches uniform to 0.0001 Inch : also a Method for Finer Subdivision having " Interesting Possibilities "].—Gall. (*Journ. of Scient. Instr.*, May 1943, Vol. 20, No. 5, p. 77.)

2512. Invar Characteristics Improved [New Grade which eliminates Machining Difficulties].—Carpenter Steel Company. (*Communications*, March 1943, Vol. 23, No. 3, p. 52 : paragraph only.)

2513. Gold Alloy for Use in Small Parts Manufacture [Electrical Contacts, Instrument Bearings, etc : Gold/Platinum/Palladium].—J. M. Ney Company. (*Scient. American*, March 1943, Vol. 168, No. 3, p. 134.)

2514. AMERICAN-MADE SAPPHIRES, *and* GLASS INSTRUMENT JEWELS.—Linde Air Products: General Electric. (*Review Scient. Instr.*, April 1943, Vol. 14, No. 4, p. 121: p. 121.)

2515. TESTING FOR PRESENCE OF CHLORIDE-CONTAINING FLUX ON SOLDERED JOINTS: PORTABLE TEST KIT REVEALING ONE-MILLIONTH OF A GRAMME.—(*Bell Lab. Record*, May 1943, Vol. 21, No. 9, pp. 277 and 282.)

2516. PRACTICAL AND ADVANTAGEOUS SOLDERING BY MEANS OF CARBON [Use of the "Soldering Pencil" in place of the Soldering Iron].—Kirsch. (*Funk* [Berlin], 1st/15th Oct. 1942, No. 19/20, pp. 275–276.)

An editorial note points out that at the present moment it is particularly important to raise output by the use of suitable equipment and tools: the light weight and handiness of the "soldering pencil" serves this purpose. Other advantages are its immediate readiness for action and its low current consumption—a saving of from 50 to 90% compared with an equivalent soldering iron: in the course of the article further advantages are pointed out, such as simpler maintenance, economy in solder (the carbon takes up no solder) and avoidance of waste of copper, and the low, safe voltage of 4.0 to 6.3 v. Two simple ways of using carbon rods as soldering irons are first discussed, and then the perfected device, the "soldering pencil", is described and illustrated: it consists essentially of two carbon electrodes (obtained by sawing a rod into two half-cylinders and combining these again with an intermediate layer of insulating cement mixture) enclosed in a suitable insulating sheath, with provision for making contact between the flexible supply cable and the two carbons. Immediately the point of the "pencil" touches the metal part close to the soldering point, the necessary localised heat is generated. The combined carbon rod varies in diameter from 3 to 6 mm according to the type of work for which the "pencil" will be used. Wear on the carbon amounts to something like 1 mm for 1000 soldered junctions.

STATIONS, DESIGN AND OPERATION

2517. SWISS METRIC- AND CENTIMETRIC-WAVE SETS MADE BY THE HASLER A.G.—Wehrlin: Tank. (*Bull. de l'Assoc. Suisse des Élec.*, 3rd June 1942, Vol. 33, No. 11, pp. 323–325: in German.) In the Discussion (illustrated) of Tank's survey dealt with in 1555 of May.

2518. "FREQUENCY MODULATION" [Book Review].—Hund. (*Review Scient. Instr.*, April 1943, Vol. 14, pp. 103–104.)

2519. U.S. ARMY SETS: PORTABLE TRANSMITTER-RECEIVERS.—(*Wireless World*, July 1943, Vol. 49, No. 7, pp. 196–197.)

2520. WIRELESS EQUIPMENT OF THE ENEMY AIR FORCES [Illustrated Survey of Polish, French, British, & Russian Apparatus, with Critical Comments].—Hepcke. (*E.T.Z.*, 5th Nov. 1942, Vol. 63, No. 43/44, pp. 505–510.)

2521. WERS [War Emergency Radio Service] IN THE NEW HAVEN WARNING DISTRICT: SOME OF THE PROBLEMS OF DISTRICT NET OPERATION.—Fraser & Keating. (*QST*, May 1943, Vol. 27, No. 5, pp. 30–31 and 80.)

2522. EMERGENCY RADIOTELEPHONE SYSTEM DESIGNED TO BRIDGE BREAKS IN WIRE LINES [with Speech-Inversion Equipment available as Auxiliary Unit, to ensure Privacy of Conversation].—Phillips. (*Communications*, March 1943, Vol. 23, No. 3, pp. 38..42 and 76.) Developed by the Bell Telephone Laboratories.

2523. WIRE BROADCASTING: SIR ROBERT WATSON-WATT'S "PIPE DREAMS" [Summary of Radio Industries Club Address & Subsequent Discussion: the "Four Freedoms" for the Broadcast Listener].—Watson-Watt. (*Wireless World*, July 1943, Vol. 49, No. 7, p. 207.)

2524. *Wireless World* BRAINS TRUST: WIRE OR WIRELESS?—"Radiophare": Eckersley. (*Wireless World*, July 1943, Vol. 49, No. 7, pp. 205–206.)

2525. HIGH-FREQUENCY WIRE BROADCASTING IN SWEDEN [with Data on Line Measurements and Description of Apparatus].—Esping & Müller. (*Lorenz-Berichte*, July 1941, No. 1/2, p. 14 onwards.) With 22 diagrams. For an earlier paper *see* 917 of 1941.

2526. HIGH-FREQUENCY WIRE BROADCASTING.—Eisele. (*Funktech. Monatshefte*, No. 4, 1941, p. 55 onwards.) For a long summary see *Bull. de l'Assoc. Suisse des Élec.*, 25th March 1942, Vol. 33, No. 6, pp. 174–176: in German. For other papers *see* 3544 of 1941 and 1548 of 1942.

2527. BROADCASTING AS A CONSUMER OF ELECTRICAL ENERGY [World Data for 1939, Stations & Receivers].—(*See* 2378.)

MISCELLANEOUS

2528. CYCLES AS AN AID TO POST-WAR PLANNING.—Dewey. (*Gen. Elec. Review*, May 1943, Vol. 46, No. 5, pp. 264–268.) By the Director, Foundation for the Study of Cycles. *See* also Editorial, p. 263.

2529. INVESTIGATIONS ON THE SEPARATION OF CLOSELY ADJACENT MAXIMA.—Hermann. (*Ann. der Physik*, 7th Feb. 1943, Vol. 42, No. 5, pp. 378–388.)

Primarily in connection with an X-ray Fourier synthesis of oxalic acid dihydrate crystals. Author's summary:—"The accuracy is investigated with which a superposition of two symmetrical maxima can be separated into its two components. It is found that with small errors in the coordinate construction of the one component a satisfactory separation can always be obtained through compensating errors in the other coordinates and in the two amplitudes and breadths. Moreover, the law of the relation between these different errors is established, which allows the separation to be made unequivocal, on the basis of a further condition which must be fulfilled by the separated components." Regarding Doetsch's earlier results (ref. " 1 "), to which his attention has now been called, the writer finds that both the methods given by Doetsch work perfectly when the curve under investigation is an exact mathematical superposition of Maxwellian distributions : when, however, it is merely an empirical curve of limited accuracy the errors given by both the methods are greatly increased and may lead to mistakes in the position, height, and even the number of the components. In such cases the writer's method is superior.

2530. STANDARD CURVES.—Hansel. (*Phil. Mag.*, June 1943, Vol. 34, No. 233, pp. 361–376.)

" One standard curve representing $Y = f(X)$ may represent all curves of the same type $y = f(px)$ by a suitable transformation of scales. This transformation is a simple projection of $[X]$ into $[x]$ in the case of the transformation described. The method of scale transformation gives useful results :—(1) it leads to a general solution of any quadratic or cubic equation having real coefficients. (2) It enables the evaluation of functions to be rapidly carried out by graphical methods. (3) It provides an accurate method of obtaining derived and integral curves. (4) It provides a method of studying errors and deviations which does not involve laborious computation. . . ."

2531. MECHANICAL INTEGRATION IN THE SOLUTION OF ELECTRICAL PROBLEMS [Kelvin Lecture]. —Hartree. (*Electrician*, 7th May 1943, Vol. 130, No. 3388, pp. 469–471 : summary only.)

2532. " POISSON'S EXPONENTIAL BINOMIAL LIMIT : TABLE I—INDIVIDUAL TERMS : TABLE II—CUMULATED TERMS " [Book Review].—Molina. (*Journ. Applied Phys.*, May 1943, Vol. 14, No. 5, p. 222.) " It need hardly be emphasised that the tables are especially welcome in the present emergency when quality control in production is of paramount importance. . . ."

2533. QUALITY CONTROL [Warning of Need for Careful Investigation of Particular Case before Changing an Existing System].—(*Engineering*, 2nd July 1943, Vol. 156, No. 4042, p. 14.)

2534. " STATISTICAL MATHEMATICS " [Second Edition : Book Review].—Aitken. (*Journ. Applied Phys.*, May 1943, Vol. 14, No. 5, p. 223.) " This volume from the series of small University Mathematical Texts [*see* 616 of 1941] is destined to rank as a classic. . . ."

2535. ON THE STATISTICS OF RANDOM DISTRIBUTIONS OF PAIRED EVENTS, WITH APPLICATIONS TO THE RESULTS OBTAINED IN THE USE OF THE INTERVAL SELECTOR WITH PARTICLE COUNTERS.—Feather. (*Proc. Cambridge Phil. Soc.*, June 1943, Vol. 39, Part 2, pp. 84–99.)

2536. EVALUATION OF TIME/SPACE RECORDS BY THE SIMULTANEOUS EMPLOYMENT OF INSTRUMENTS OF DIFFERENT TYPES.—Knobloch. (*Journ. Roy. Aeron. Soc.*, June 1943, Vol. 47, No. 390, pp. 296–297.) R.T.P.3 Abstract.

2537. " MATHEMATICS OF MODERN ENGINEERING : VOLUME II—MATHEMATICAL ENGINEERING " [Book Review].—Keller. (*Review Scient. Instr.*, April 1943, Vol. 14, No. 4, pp. 111–112.)

2538. " ELECTROMAGNETIC WAVES " [Book Review].—Schelkunoff. (*See* 2295.)

2539. " EXPERIMENTAL ELECTRONICS " [Book Review].—Müller, Garman, & Droz. (*Review Scient. Instr.*, April 1943, Vol. 14, No. 4, p. 99.)

2540. " A COURSE IN RADIO FUNDAMENTALS " [Book Review]. — Grammer. (*Electronic Eng:g*, June 1943, Vol. 16, No. 184, p. 38.) This book is reprinted from the series in *QST* : it includes assignments, examination questions and answers, etc.

2541. " PRE-SERVICE COURSE IN SHOP PRACTICE " [Book Review].—Kennedy. (*QST*, May 1943, Vol. 27, No. 5, p. 80.)

2542. *QST* RETURNS TO GALLUPS ISLAND : HOW MARINE RADIO OPERATORS ARE TRAINED UNDER THE U.S. MARITIME SERVICE.—De Soto. (*QST*, May 1943, Vol. 27, No. 5, pp. 14–18 and 84..90.)

2543. NEW METHOD OF TEACHING : " SYNCHROPHONE " AS MECHANICAL AID TO TECHNICAL INSTRUCTION.—Sandor. (*Electrician*, 2nd July 1943, Vol. 131, No. 3396, pp. 19–20.)

2544. MODELS SPEED WAR PRODUCTION [by aiding in Visualisation of Complicated Apparatus in Completed Form, and by helping to solve Problems in Design & Equipment Layout]. —Chesebro. (*Gen. Elec. Review*, May 1943, Vol. 46, No. 5, pp. 271–273.)

2545. EDUCATION AND TRAINING FOR ENGINEERS [Report of I.E.E. Sub-Committee].—(*Journ. I.E.E.*, Part I, June 1943, Vol. 90, No. 30, pp. 223–233 : *see* also p. 211.) A summary was referred to in 2021 of July.

2546. THE UNIVERSITY EDUCATION AND INDUSTRIAL TRAINING OF ENGINEERS, WITH PARTICULAR REFERENCE TO TELECOMMUNICATIONS.—Willis Jackson. (*Journ. I.E.E.*, Part III, June 1943, Vol. 90, No. 10, pp. 53–60 : Discussion pp. 61–72.) A summary was referred to in 1332 of April.

2547. NATIONAL RESEARCH [Summary of Address to Parliamentary & Scientific Committee].—Cripps. (*Engineer*, 2nd July 1943, Vol. 176, No. 4564, p. 17.)

2548. THE MOBILISATION OF SCIENCE [Bill introduced in U.S. Senate, read twice & referred to Committee on Military Affairs].—(*Science*, 7th May 1943, Vol. 97, No. 2523, pp. 407–412.) *See* also *ibid.*, 23rd April, No. 2521, pp. 375–377 (Elliott & Grundfest). For a critical Editorial see *Journ. Applied Phys.*, May 1943, Vol. 14, No. 5, p. 203.

2549. A SURVEY OF SELECTION AND ALLOCATION FOR ENGINEERING OCCUPATIONS.—Holliday. (*Journ. Roy. Aeron. Soc.*, May 1943, Vol. 47, No. 389, pp. 228–229.) R.T.P.3 Abstract.

2550. RESEARCH IN WARTIME.—Simons. (*Science*, 30th April 1943, Vol. 97, No. 2522, pp. 390–392.)

"The day that fundamental and original scientific research stopped in Germany was the day that Germany began losing the war. This will be true provided that we do not stop our fundamental scientific research. We are in great danger of doing this at this time, with our scientists being taken for development projects and other activities. . . ."

2551. NATIONAL LEARNED SOCIETY GROUPS AND THE PUBLIC INTEREST [and the Problem of Private Contracts with Great Corporations].—Karpinski. (*Science*, 7th May 1943, Vol. 97, No. 2523, pp. 422–423.)

2552. THE SCARCITY OF SCIENTIFIC APPARATUS [and the Functions of the Electronic Research Supply Agency]. — (*Science*, 23rd April 1943, Vol. 97, No. 2521, Supp. pp. 10 and 12.)

2553. SCIENCE, SCIENTISTS, AND SOCIETY.—Mellon. (*Science*, 23rd April 1943, Vol. 97, No. 2521, pp. 361–368.)

2554. EDUCATION FOR CITIZENSHIP: AN AMERICAN MANIFESTO [Editorial on "Education for Citizen Responsibilities"]. — (*Nature*, 1st May 1943, Vol. 151, No. 3835, pp. 483–485.)

2555. STANDARDISATION AND ELECTRICAL ENGINEERING: 25 YEARS OF THE GERMAN STANDARDS COMMITTEE, 50 YEARS OF THE V.D.E.—Wagner. (*See* 2471.)

2556. THE "TECHNICAL EMERGENCY REPAIR ORGANISATION" [Technische Nothilfe] ON THE AIR FIELDS IN THE OCCUPIED WEST [Work of the "T.N. Special Commando L," organised in 1940 for the Luftwaffe].—Schäfer. (*E.T.Z.*, 3rd Dec. 1942, Vol. 63, No. 47/48, pp. 561–564.)

2557. BOMB SCORING MADE MORE ACCURATE BY MICROPHONE METHOD [at Bombardier College: "Sonic Method" developed from Seismic Prospecting Technique].—McKaba. (*Scient. American*, March 1943, Vol. 168, No. 3, pp. 128–129.)

2558. TEST-FLIGHT RADIO RECORDER [a Vultee Aircraft Development]. — Peters: Giffen. (*Communications*, March 1943, Vol. 23, No. 3, pp. 44..49 and 77.) Concluded from 2031 of July.

2559. VULTEE FLIGHT TEST RECORDER.—(*Journ. Roy. Aeron. Soc.*, June 1943, Vol. 47, No. 390, p. 295.) R.T.P.3 Abstract. *See* also 2558, above.

2560. FLOATING RADIO ROBOTS FOR OCEAN-CURRENT SURVEYS.—Colbert. (*Science*, 7th May 1943, Vol. 97, No. 2523, Supp. p. 12.)

2561. LEADER CABLES [Magnetic Field of a Cable in Neighbourhood of Ground: Field of a Leader Cable, and Its Polarisation: Elimination of False Cables: etc.].—Raymond. (*See* 2402.)

2562. MAHOMET TO THE MOUNTAIN [Suggested Propaganda Method over Enemy Countries]. —"Free Grid." (*Wireless World*, July 1943, Vol. 49, No. 7, p. 214.)

2563. FUTURE OF BROADCASTING: PREPARING FOR POST-WAR RECONSTRUCTION [Editorial: Fruitlessness of Usual Criticism: Fundamental Issues Ignored: Need for the Spur of Competition: Ineffectiveness of Promised "Friendly Competition between Regions": etc.].—(*Wireless World*, July 1943, Vol. 49, No. 7, p. 191.)

2564. INVISIBLE RAYS DRY MOULDS FOR WAR CASTING [Use of Infra-Red Radiation for drying Green Sand Moulds reduces Labour Requirements by Three-Fourths].—Duryee. (*Sci. News Letter*, 15th May 1943, Vol. 43, No. 20, p. 312.)

2565. DISCUSSION ON "ELECTRONICS IN INDUSTRY" [at Wireless Section Informal Meeting].—Cattanes, Winch, & Whiteley. (*Journ. I.E.E.*, Part III, June 1943, Vol. 90, No. 10, pp. 72–73.)

2566. NEW WELDING METHOD [in American Aeroplane Construction: with Electronic Time-Control].—Vedder. (*Journ. Applied Phys.*, May 1943, Vol. 14, No. 5, p.x.) From the Westinghouse Company.

2567. STEEL-MAKING RECEIVES ELECTRONIC SCIENCE WITH OPEN ARMS.—Caldwell. (*Scient. American*, Feb. 1943, Vol. 168, No. 2, pp. 60–61.)

2568. CREEP OF METALS MEASURED BY ELECTRONICS [Optical Grating Method with Photocell/Inkwriter Recording]. — Malpica. (*Scient. American*, March 1943, Vol. 168, No. 3, pp. 124 and 126.) From the General Electric laboratories.

2569. APPLICATION OF SUPERSONICS IN METALLURGY [in Soldering of Tinned Aluminium Sheet: to produce Finer Grain in Castings:

Self-Lubricating Bronze]. — (*Journn. Roy. Aeron. Soc.*, May 1943, Vol. 47, No. 389, p. 219–220.) R.T.P.3 Abstract. *Cf.* Becker, 1358 of April.

2570. On the Applications of the Glow Discharge in Metallurgy [Experiments on Carburization of Steel, etc.].—Saito. (*Electrotech. Journ.* [Tokyo], April 1941, Vol. 5, No. 4, p. 80.)

2571. Electronic Soldering Method [Valve-Generated Induction Heat replaces Gas Heat in Soldering of Crystal Units].—Jordan: General Electric. (*Proc. I.R.E.*, April 1943, Vol. 31, No. 4, p. xl.) For a long paper *see* 975 of March.

2572. Radio Waves "spot-weld" Lumber with Special Glue [for converting Narrow Waste Stock into Wide Boards].—Laucks, Inc. (*Sci. News Letter*, 27th March 1943, Vol. 43, No. 13, p. 201.) *Cf.* 975 of March and 1576 of May.

2573. Tin Fusing by Radio Waves: High-Frequency Treatment of Tinned Plate.—Westinghouse. (*Electrician*, 30th April 1943, Vol. 130, No. 3387, p. 451.) *See* also 1553 of May and 2037 of July.

2574. High-Frequency Field used in Metal Work [Case-Hardening, Tin-Plate Polishing, also Heat Treatment of Tobacco in Hogshead and Killing of Insects in Grains & Cereals].—(*Sci. News Letter*, 15th May 1943, Vol. 43, No. 20, p. 319.)

2575. Recording Dilatometer for Metal Specimens [in Investigation of Austempering of Steels: suitable for Runs up to a Week as well as Short Runs of Hour or Two: Range of Changes of Length about 0.2 mm: Kent Recorder, Moullin Valve-Voltmeter (slightly modified), & Capacitance-Change Device].—Stanton. (*Engineering*, 25th June 1943, Vol. 155, No. 4041, pp. 518–519.)

2576. "The Use of Secondary Electron Emission for Trigger on Relay Action" [Notice of Pamphlet].—Skellett. (*See* 2329.)

2577. A Direct-Current Amplifier [or Electronic Relay] and Its Application to Industrial Measurements and Control.—Gall. (*Journn. I.E.E.*, Part II, Oct. 1942, Vol. 89, No. 11, pp. 434–443: Discussion pp. 443–446.) A summary was referred to in 1586 of 1942.

2578. Some Industrial Applications of Electronics [Negative-Feedback Results remove One of the Major Arguments against Valves for Control Equipment: Vibration Analysers (and Negative-Feedback *RC* Amplifier as Substitute for Crystal Gate): Stable Oscillators (and a Set-Up for Series of Frequencies about 100 c/s, differing by Exactly 1 c/s): Clock Timing (*see* also Discussion): Micrometers: Turbo-Alternator Vibrations: Precise Adjustment of Magnet Strengths: etc.].—Reyner. (*Journn. British Inst. Rad. Eng.*, March/May 1943, Vol. 3, No. 4, pp. 160–169: Discussion pp. 169–174.)

For M. Lévy's remarks on his pioneer work on negative feedback *see* 2327, above. He also gave experimental curves indicating that the frequency-stabilising effect of a parallel diode on an *RC* oscillator is not very great: a triode (Figs. 10, 11) was completely successful. Sherman discusses crystal vibration pick-ups as distinct from the gramophone type.

2579. Technical Conditions for Apparatus and Appliances for the Electrical Reproduction of Sound and Pictures and for Telecommunication and Telecontrol [Proposed Regulations: including Diagram of the "Exploring Finger" for testing the "Touchability" of Dangerous Parts].—A.S.E. (*Bull. de l'Assoc. Suisse des Élec.*, 6th May 1942, Vol. 33, No. 9, pp. 266–268: in German.)

2580. Special Issue on Telemetering and Telecontrol.—Schwartz & others. (*Bull. de l'Assoc. Suisse des Élec.*, 31st Dec. 1941, Vol. 32, No. 26, pp. 741–808.) Including a paper by Schwartz on carrier-current communication and the influence and measurement of the total attenuation and characteristic impedance of the lines (pp. 782–786).

2581. "Temperature Control" [Book Review].—Ansley. (*Proc. Phys. Soc.*, 1st May 1943, Vol. 55, Part 3, No. 309, p. 256.) For an extremely critical review see *Current Science* [Bangalore], March 1943, p. 91.

2582. Electronic Motor Control ["Thy-mo-Trol" System, for Adjustable-Speed D.C. Motor Drive with Close Speed Regulation, Smooth Acceleration, & Precise Control of Speed].—Fendley. (*Gen. Elec. Review*, April 1943, Vol. 46, No. 4, pp. 225–230.)

2583. A Clock-Controlled Governor for Close Speed Regulation [for Carrier-Wave Alternators, Motors operating Astronomical Telescopes, etc.]. — Prescott & Karaosman. (*Journn. I.E.E.*, Part II, June 1942, Vol. 89, No. 9, pp. 210–216.)

"The speed of an electric motor is synchronised with a pendulum clock, and it is shown that the arrangement will apply corrections for speed deviations as small as ± 0.03% on nominally constant loads, and will correct variations as large as ± 7.5% which may be caused by changing loads." For a short Discussion *see* issue for Oct. 1942, No. 11, p. 520: this includes two corrections.

2584. Correspondence on "The Electro-Mechanical Analogy in Oscillation Theory" [1314 of April].—Aughtie & Cox: Manley. (*Journn. Roy. Aeron. Soc.*, May 1943, Vol. 47, No. 389, pp 161–162.)

2585. Experiments with Piezoelectric Pressure Indicators [Kink in Calibration Line of Design commonly used for Gas Pressures in Guns avoided by Writer's Design].—Hackemann & others. (*Journ. Roy. Aeron. Soc.*, May 1943, Vol. 47, No. 389, pp. 227–228.) R.T.P.3 Abstract.

2586. "Service Manual of the Waugh Laboratories" [dealing with Various Types of Less Common Testing Instruments (Strain, Vibration & Sound, Motion Studies, Heavy Impact, etc: Book Notice].—(*Review Scient. Instr.*, March 1943, Vol. 14, No. 3, p. 80.)

2587. Generator "Watchman" detects and records Vibrations in Rotating Shafts [Device the Size of Large Box Camera, with Babbit-Tipped Rod touching the Shaft: Generator, Amplifier, & Pen Recorder].—Werner. (*Scient. American*, March 1943, Vol. 168, No. 3, pp. 106–107.) From the Westinghouse laboratories.

2588. Telephone Alarm used to summon Air-Raid Warden from Workshop [Zenith "Electric Sentry" Transmitter plugged into Mains near Telephone Bell, Receiver into Mains in Workshop (or Neighbouring House)].—Dickie. (*Scient. American*, March 1943, Vol. 168, No. 3, p. 123.)

2589. Smoke Density Measurement using Photocells [Practical Circuits: Performance (including Curve of Photocell Illumination in relation to Indicator Pointer Movement and Ringelmann Scale of Smoke Densities): Constructional Features: Bibliography].—Wey. (*Electronic Eng:g*, May 1943, Vol. 15, No. 183, pp. 507–508 and 513, 514.) *See* also 1868 of 1942.

2590. Direct-Reading Photoelectric Speed Counter.—A.E.G. (*E.T.Z.*, 19th Nov. 1942, Vol. 63, No. 45/46, Advt. p. 9.)

2591. A Photoelectric Voltage-Control Gear.—Samson. (*See* 2482.)

2592. Data Sheet of Spectral Response Curves [including Photocathodes], *and* The Spectral Response of Photoelectric Cells [including the Baird Type A (Antimony) & Type B (Bismuth)].—(*See* 2446 & 2447.)

2593. A Table of American Photocells, *and* The R.C.A.931 Multiplier Photocell.—(*See* 2448 & 2449.)

2594. Some Measurements on Selenium Photocells.—Veszi. (*See* 2450.)

2595. A New Spectroscopic Source Unit.—Hasler & Dietert. (*Journ. Optical Soc. Am.*, April 1943, Vol. 33, No. 4, pp. 218–228.)

Developed to fulfil the following requirements:—condenser should be charged to a definite voltage before each gap breakdown, thus ensuring reproducibility of quantity of electricity available for each discharge: only the analytical gap in the discharge circuit, thus allowing the termination of the discharge to be dependent only on the circuit and gap constants: L, C, R conditions such that discharges both oscillatory and unidirectional can be varied from time-durations similar to those obtained with the ordinary spark unit to durations of milliseconds, to give a wide variety of excitation conditions ranging from spark to arc.

2596. Fluorescent Lamps.—Davies, Ruff, & Scott. (*Journ. I.E.E.*, Part II, Oct. 1942, Vol. 89, No. 11, pp. 447–465: Discussion pp. 465–472.)

2597. The Physics and Technique of the Krypton Lamp.—Reiter. (*E.T.Z.*, 3rd Dec. 1942, Vol. 63, No. 47/48, pp. 553–557.)

2598. "Photography as an Aid to Scientific Work" [Notice of Booklet].—Ilford, Limited. (*Engineering*, 2nd July 1943, Vol. 156, No. 4042, p. 10.)

2599. A Method for Removing Microscopic Fog from Photographic Plates.—Liebermann & Barschall. (*Review Scient. Instr.*, April 1943, Vol. 14, No. 4, pp. 89–90.)

2600. Third Dimension: Effect obtained with Conventional Movie Camera [by use of the "Swing Mount"].—Bickley. (*Scient. American*, June 1943, Vol. 168, No. 6, p. 266.)

2601. The A.E.G. Light-Flash Stroboscope.—A. E. G. (*E.T.Z.*, 5th Nov. 1942, Vol. 63, No. 43/44, Advt. p. 9.)

2602. Amplifying and Recording Technique in Electro-Biology: Part II—The Electrical Activity of the Human Brain [including the Analysis of Records (Grass's Cine-Film/Wave-Analyser Method is liable to neglect Transients: Promising Results with Tuned Reeds prolonged into Pens): Bibliography].—Parr & Grey Walter. (*Electronic Eng:g*, May 1943, Vol. 15, No. 183, pp. 519–522.) An I.E.E. paper.

2603. An Automatic Low-Frequency Analyser [using Tuned Reeds as Frequency Splitters, with Photoelectric or Mercury-Cup Storage: primarily for Electroencephalographic Research but adaptable to A.F. or Vibration Phenomena].—Grey Walter. (*Electronic Eng:g*, June 1943, Vol. 16, No. 184, pp. 9–13.) Provisionally patented.

2604. Wave Analysis: Part III—Analysis of Periodic Wave-Forms.—Bourne. (*See* 2421.)

2605. Western Electric Sound Frequency Analyser used by an Explosive Manufacturer [to detect Heart Fatigue caused by Chemical Fumes, where Stethoscope fails].—(*Bell Lab. Record*, May 1943, Vol. 21, No. 9, pp. 305–306.)

2606. The Electrical Amplifying Stethoscope and Phono-Electrocardioscope.—Donovan. (*Journ. I.E.E.*, Part III, June 1943, Vol. 90, No. 10, pp. 38–49: Discussion pp. 49–52.)

The writer quotes the eight "laws governing auscultation" stressed by Rappaport & Sprague and adds three of his own, based on human weakness. He continues: "From the material presented so far, we may conclude that the human ear in auscultation has many faults. . . ." Author's summary:—"The important factors are discussed. A new method is described for the direct visual observation of the phonocardiogram accompanied by a simultaneous electrocardiogram, or phonocardiogram *plus* sphygmogram, etc., at the patient's bedside. The heart sounds can be heard at the same time through a special electrical stethoscope which is incorporated in the apparatus."

2607. A Method of determining Biological Inter-Electrode Impedances [Objections to Ohmmeter & Bridge Methods: a Constant-Current Method recording Results directly on to the Tracing of the Phenomenon under Investigation].—Saunders. (*Electronic Eng:g*, May 1943, Vol. 15, No. 183, p. 524.)

2608. Effect of Visual and Taste Stimuli upon the Muscular Tonus in Man [Experimental Investigation, with Deductions: Reason for the Enhancing (in Some Cases) or Inhibiting (in Others) Action of the Accessory Stimulus].—Margolin. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, 20th Oct. 1941, Vol. 33, No. 2, pp. 125–128: in English.)

2609. Water Divining: Its Alleged Electrical Basis.—Shipley. (*Distribution of Elec.*, July 1943, Vol. 16, No. 151, pp. 140–141 and 145.) Concluded from 2040 of July.

2610. Radio-Prospection: Physical Bases of Water Divining.—Maby. (*Distribution of Elec.*, July 1943, Vol. 16, No. 151, pp. 164–165 and 168.)

2611. Amplifiers and Mains Units for the Supply of Counter Tubes.—Rehbein. (*E.T.Z.*, 5th Nov. 1942, Vol. 63, No. 43/44, p. 519.) A longer summary of the paper dealt with in 1539 of May.

2612. Crystallography for Routine Analysis.—Walker. (*Engineer*, 18th June 1943, Vol. 175, No. 4562, pp. 492–494.) From the *Metropolitan-Vickers Gazette*.

2613. X-Ray Analysis in Industry [Institute of Physics' Conference].—(*Nature*, 1st May 1943, Vol. 151, No. 3835, pp. 506–508.)

2614. Industrial Research Laboratory of the University of Rochester [with Million-Volt X-Ray Unit: Opened on 19th April].—(*Science*, 30th April 1943, Vol. 97, No. 2522, pp. 395–396.)

2615. High-Temperature X-Ray Camera [for Investigation of Phase Changes with respect to Temperature in Certain Organic Compounds (Sodium Stearate, etc.)].—de Bretteville. (*Journ. Applied Phys.*, March 1943, Vol. 14, No. 3, p. 137: summary only.)

2616. The Influence of Physics on Chemistry.—Darrow. (*Bell Lab. Record*, May 1943, Vol. 21, No. 9, pp. 284–289.)

2617. Modern Uses for Wind Power: Latest Developments in Direct-Driven Air-Screw Plant.—(*Electrician*, 14th May 1943, Vol. 130, No. 3389, pp. 487–488.) *See* also letter from Cameron Brown, *ibid.*, 25th June, No. 3395, pp. 647–648; and 2618, below.

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